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# Assessment of Cold-Climate Environmental Research Priorities

Battelle Pacific Northwest Labs., Richland, WA

Prepared for

Corvallis Environmental Research Lab., OR

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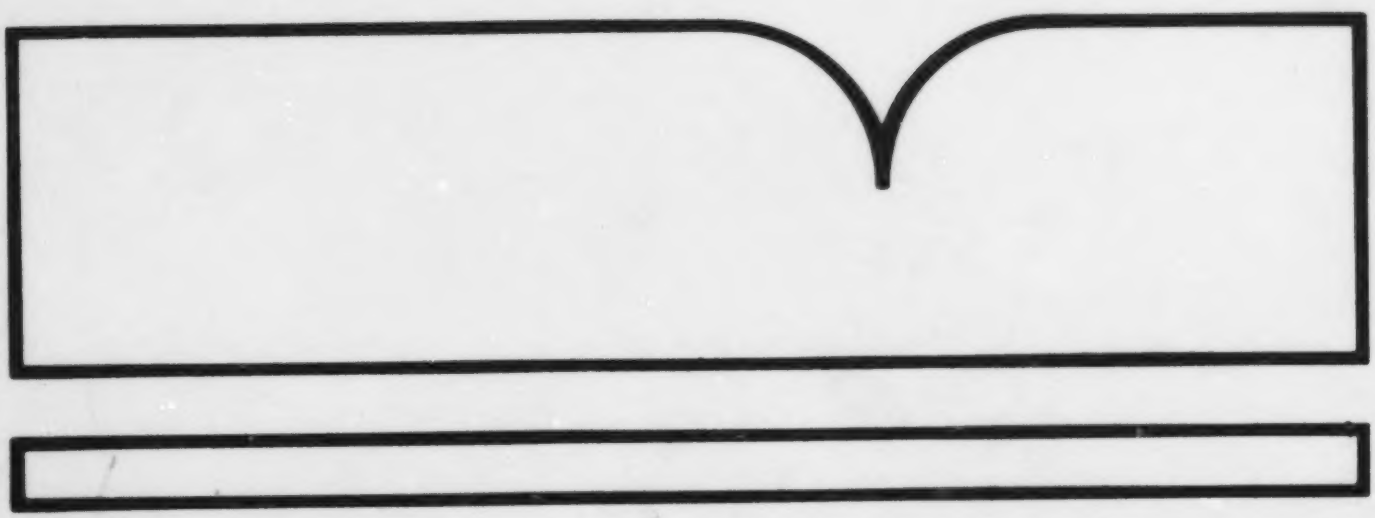

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16. ABSTRACT

Since its inception, the U.S. Environmental Protection Agency has maintained a research program in Alaska to address environmental problems unique to cold climates. The wide range of natural resource developments now being considered pose an equally wide range of possible environmental and related human health problems. In response to identified needs for planning, the EPA asked the Pacific Northwest Laboratory to establish a sound conceptual framework and work plan for a three to five year cold climate environmental research program. This planning process identified the 15 highest priority issues. The overall objective of the process was to provide the pertinent information an EPA contractor would need to start work immediately. Where the state of knowledge was so poorly developed that the specificity called for in the outline could not be provided, ways were suggested to address the uncertainty. Eighteen plans are presented in the report.

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# ASSESSMENT OF COLD-CLIMATE ENVIRONMENTAL RESEARCH PRIORITIES

J. B. States

February 1983

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ASSESSMENT OF COLD-CLIMATE RESEARCH PRIORITIES

## EXECUTIVE SUMMARY

Since its inception, the U.S. Environmental Protection Agency (EPA) has maintained a research program in Alaska to address environmental problems unique to cold climates. The wide range of natural resource developments now being considered pose an equally wide range of possible environmental and related human health problems. Given the number of potential problems, severe limitations on fiscal resources, and a diversity of opinion on which environmental problems are most important, considerable controversy has been generated within and outside the EPA by those concerned with the relevance and effectiveness of the EPA's continuing programs. Major criticisms have pointed out that: 1) research priorities have been established largely by a select "in-group" and have not been broadly representative of existing needs, 2) component projects have often failed to provide the information needed for solving specific environmental problems under EPA jurisdiction, 3) Alaska-based supervision and coordination is needed to assure that research remains focused on an EPA need to know rather than principal investigator interests, 4) long-term planning and continuity of effort be encouraged in place of year-to-year crisis management, and 5) better advantage be taken of interagency cooperative research efforts to get more out of the limited resources available to EPA and other agencies having environmental responsibilities.

In response to these criticisms, in September 1981, the EPA asked the Pacific Northwest Laboratory (PNL) of Battelle Memorial Institute, to establish a sound conceptual framework and work plan for a three to five year cold-climate environmental research program. The approach was to:

* identify experts and parties having a vested interest in natural resource-related environmental problems through personal contacts and literature reviews,

* involve as many of these individuals as possible in collaborative planning efforts,

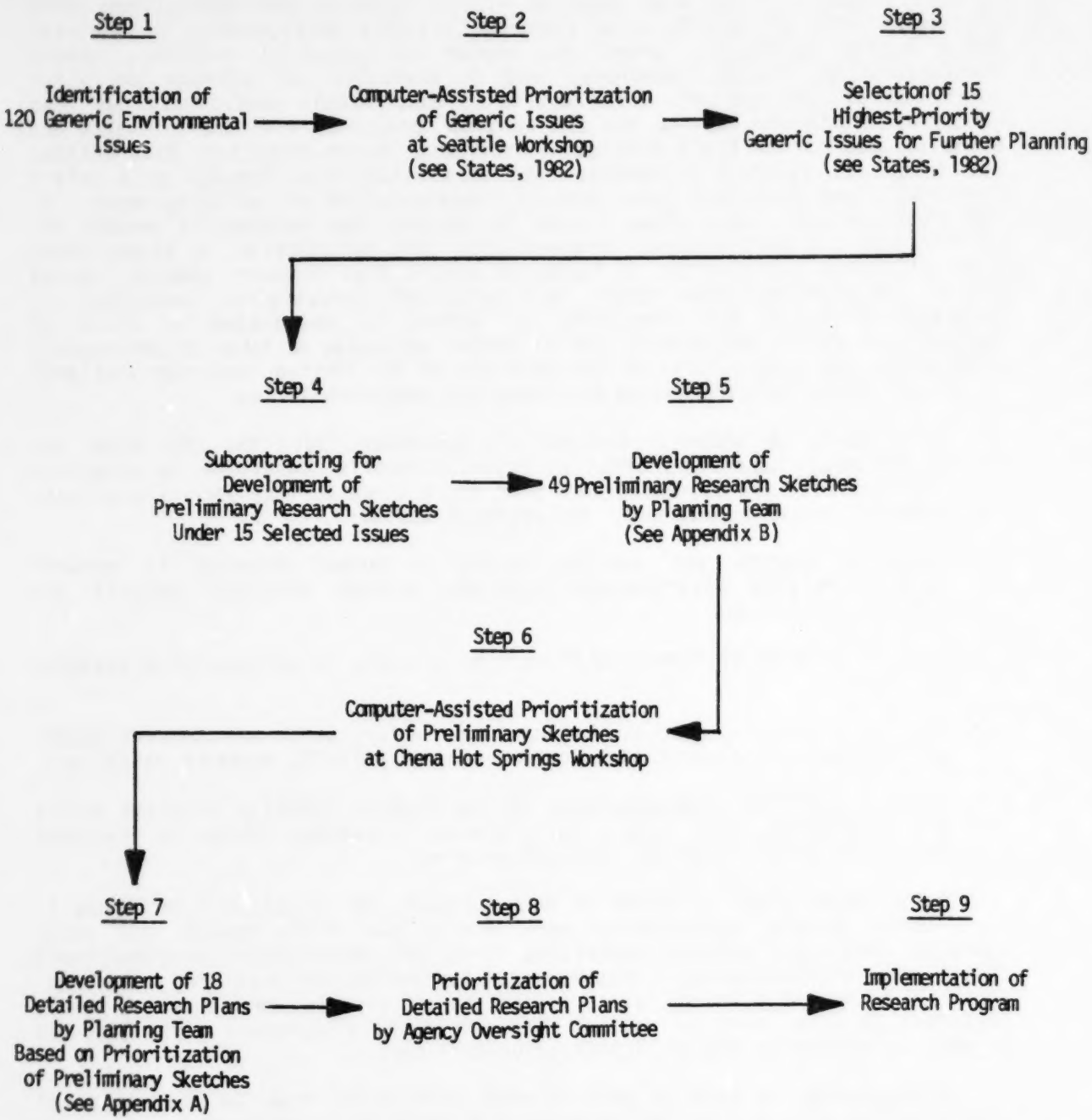
* utilize a planning process that minimizes polarization and divisive debate and achieves a representative consensus as to priority research needs, and

* develop detailed recommendations on the highest priority research topics and incorporate these into a well-focused, integrated, three- to five-year cold-climate environmental research program.

The planning steps involved in this approach are illustrated in Figure 1. Forty-three experts representing many disciplines from federal and state agencies, industry, private consulting firms and universities provided input during two workshops using a computer-assisted method for achieving consensus. In the first workshop, participants identified 120 generic, environmental issues pertinent to development of natural resources in cold climates. This list was eventually reduced to the 15 highest priority issues.

Subsequently, a team of environmental scientists from the University of Alaska and Tetra Tech, Inc. collaborated with Battelle in developing a series of

Figure 1. Steps in the Development of a Cold-Climate Research Program


Step 1
Identification of 120 Generic Environmental Issues
Step 2
Computer-Assisted Prioritzation of Generic Issues at Seattle Workshop (see States, 1982)
Step 3
Selectionof 15 Highest-Priority Generic Issues for Further Planning (see States, 1982)
Step 4
Subcontracting for Development of Preliminary Research Sketches Under 15 Selected Issues
Step 5
Development of 49 Preliminary Research Sketches by Planning Team (See Appendix B)
Step 6
Computer-Assisted Prioritization of Preliminary Sketches at Chena Hot Springs Workshop
Step 7
Development of 18 Detailed Research Plans by Planning Team Based on Prioritization of Preliminary Sketches (See Appendix A)
Step 8
Prioritization of Detailed Research Plans by Agency Oversight Committee
Step 9
Implementation of Research Program

43 preliminary research sketches for specific environmental problems identified under the 15 generic issues. These were reviewed, expanded to a list of 49, and prioritized in a second workshop. Finally, the project team was charged with developing detailed research plans for as many of the highest priority research sketches as time would allow. Where possible, elements (such as logistics or site use) from several sketches were combined to achieve greater integration and efficiency. Each research project was to be defined in terms of a series of milestones recommended by the planning team, beginning with an indication of when the research should begin and why. As much as possible, milestones were defined in terms of identifiable outputs or products to which time and dollar estimates might be tied. The final milestone was to be an estimated time to completion (including final reports). Where the milestone was an output, the nature of that output was to be indicated. The ways in which findings of the research were expected to be applied in identifying and resolving environmental problems were to be clearly specified. Attempts were to be made to anticipate who might use the information, how it might be used, and the approach (formatting, presentation, politics) by which results of the research might be applied in protecting the environment. Statements were to indicate where the answers to the questions posed could be obtained before the development activity commenced so that the results might be applied beforehand to circumvent potential problems.

The overall objective of the detailed planning process was to provide the pertinent information that an EPA contractor would need in order to start work immediately. Where the state of knowledge was so poorly developed that the specificity called for in the outline could not be provided, ways were to be suggested in which the uncertainties might be addressed and resolved creatively. The resulting 18 plans are presented in Appendix A and summarized below in four research categories (air pollution, water contamination/consumption, habitat modification/manipulation and waste disposal).

## Air Pollution Research

Air pollution topics, in general, received the highest priorities for environmental research. Major contributing factors appeared to be 1) the fact that some of these problems are not hypothetical but clear and present problems, 2) the potential for an airborne problem to be a geographically widespread problem, and 3) the potential for direct and indirect effects on human health.

### Urban Pollution -- Pollutants and Health Effects

A high-priority area of concern in urban areas is the potential for deleterious health effects from airborne particulate matter, especially from woodsmoke and vehicular emissions in different particle size ranges, particularly the respirable size range. The objectives of associated studies are to observe the time and space distribution of pollutants in Alaskan urban centers and assess their possible health effects. Studies will emphasize standard and established techniques for the collection and analysis of samples. Health implications will be determined in two ways. One is to compare observed concentrations with recommended levels. The other is to perform Ames mutagenicity and phagocyte tests to ascertain synergistic effects.

Urban Pollution -- Develop Basis for Predicting Pollutant Dispersion in Highly Stable Atmospheres

This study is proposed in two phases. Phase I is the final step in a project already underway which examines actual CO concentrations under stable inversions in urban centers in Alaska. The objective is to determine from actual case studies the type of meteorological conditions that cause CO concentrations in urban areas to increase. These data are being used to develop and calibrate a statistical model for predicting periods of high CO concentration. This is required for developing counter-measures and contingency plans for high-pollution alerts.

Phase II involves the use of an artificial tracer, sulfur hexafluoride ($SF_6$) to determine empirically the dispersion equations that apply to the stable atmospheric conditions in the arctic and subarctic atmospheres. The result will be a modified Gaussian gas/particle dispersion equation which, unlike the presently used equation, is applicable to the highly stable atmospheric conditions in Alaska.

Urban Pollution - Transportation System Characterization Study

This study was designed to test, by actual observation, the validity of several assumptions in the Fairbanks North Star Borough Air Quality Attainment Plan.

Urban Pollution -- Vehicle Emissions and Alternate Fuels (Currently Underway)

The greatest concerns expressed in research prioritization workshops dealt with potential effects on human health from air pollutants. The most immediate problem in this category is presented by two non-attainment areas (Anchorage and Fairbanks) where the EPA carbon monoxide (CO) standard has been repeatedly exceeded. These areas must be brought into compliance by 1987. Consequently, the Mobile Environmental Test Facility (METFac), now on loan to the Alaska Department of Environmental Conservation (DEC) from the EPA, is being used to conduct vehicle emission tests under low temperature conditions. This will enable the DEC and EPA to quantify the effectiveness of alternative transportation control strategies in achieving ambient air quality standards by the statutory deadline. Resulting information is expected to be useful to other cold-weather CO non-attainment areas in determining the most cost-effective ways to achieve emission reductions.

Photochemistry at High Latitudes

Ozone and photochemical irritant production are of primary concern under the EPA mission. There is evidence that assumptions regarding the lack of photochemical reactions at high latitudes may not be correct, particularly during long summer days. The urban and industrial centers of Alaska are growing, yet virtually nothing is known experimentally about photochemical activity at high latitudes (above $60^{o}$ N) anywhere in the world.

Observations of ultraviolet radiation intensity, and organic and ozone concentrations at high latitudes (65-$72^{o}$ N) in urban (Fairbanks) and industrial (Prudhoe) areas will be used to ascertain the probable duration and intensity of photochemical reactions at high latitudes.

## Industrial Pollution - Pollution Downwash and Deposition Modeling

Recent air quality dispersion modeling of gaseous pollutants emitted from gas turbines has identified that typical climatic conditions exhibited on the North Slope of Alaska may result in downwash of these pollutants to the ground surface at a relatively short distance from the point of emission. Several site-specific parameters, some of which cannot be adequately simulated by the model, control the occurrence, relative frequency and magnitude of the downwash events. As a result of the downwash activity, pollutants contained in the turbine exhaust plume impact the ground surface at a higher concentration than would normally be expected because of the limited plume transport time. A significant frequency of this downwash phenomenon may result in a much greater impact than previously projected upon the health of resident workers and terrestrial and aquatic ecosystems on the North slope of Alaska.

The primary objective of this study is to develop a predictive computer model of the stack downwash under wet and dry conditions for distances up to 100 miles in the Prudhoe area. Such a model is critically necessary to provide source term input for aquatic and terrestrial models of potential effects from acid precipitation.

## Background Studies - "Arctic Haze"

Industrial aerosols and emitted gases enter dry Eurasian air masses north of the polar front and travel over continental pathways into the high arctic regions. During transport, the aerosol removal rate is small due to the inherent stability of arctic air masses and the low amount of cloud volume available for scavenging. The purpose of these studies is to assess the concentration, composition and transport pathways of trace gases and particles imported into Alaska from Eurasia and Northeastern U.S.A. Such polluted arctic air masses reach the American Arctic and travel southward into Alaska, bringing with them residues that are characteristic of mesoscale air pollution of the kind that reaches and affects geographical areas far from emission sources (eg., the Canadian or Scandinavian acid rain problem). They are liable to prove more important in causing ecological damage than specific pollutant mixtures near source areas because they affect large areas and because they contain acid aerosol which has converted from sulfur-bearing trace gases.

## Background Studies - Natural Concentrations of Organic and Inorganic Compounds

Organic constituents in clean air over the tundra have been determined in the past, before any Prudhoe Bay activity, to be over 0.20 ppm during the summer. This is a significant fraction of the recommended limits of hydrocarbons. It is nearly equal to the once-a-year, three-hour concentration guideline of 0.24 ppm of hydrocarbons in urban air. Some of the questions are, how extensive is the phenomenon in the Arctic and Subarctic, in area and in time? Are these organic compounds of the type that will induce photochemical activity?

The objectives of this study are to determine what natural concentrations of organic and inorganic compounds arrive at industrial and urban sites in the Arctic and Subarctic. In some cases, this is an important fraction of the pollutant load normally associated with human activity.

## Summary and Synthesis of Cold-Climate Air Pollution

At the beginning of the project there is a need to compile a synthesis of all available information on air pollution in Alaska. This is to include sources of pollutants, chemical characteristics, transport, effects of the pollutants and mitigative measures taken to date. Towards the end of the project a similar synthesis should be performed. This is to be an assessment of the air pollution potential and problems for the entire state. The literature search will include EPA and DEC papers and files on the subject as well as those at the University of Alaska and other institutions. Published papers, reports and unpublished material from foreign sources, particularly Canada and Scandinavia, will also be included.

## Water Contamination/Consumption Research

Water-borne pollution is second only to airborne pollution in its potential for wide geographic dispersal and effects upon man, both direct and indirect. Hence, water-borne problems received considerable attention in the two workshops.

### Asbestos Levels in Alaskan Drinking Water

Asbestos is a carcinogenic agent to which exposure occurs from inhalation and ingestion. The amount of asbestos in the Yukon River reaches a level higher than those associated with an increased risk of developing cancer from ingestion. Exposure in the region of the Yukon could occur not only from drinking the river water, but also from eating asbestos-laden fish from the river as well as inhalation of wind-blown dust from river banks and alluvial deposits in the region around the river.

This research is directed towards determining the concentration of asbestos in selected Alaskan rivers and in the other drinking water sources to estimate the extent of exposure of the village populations to asbestos. The data on the levels of asbestos in the rivers and other drinking water sources will indicate to what extent hazardous amounts of asbestos are present. A preliminary survey of Alaskan geology and asbestos mining claims indicates that other rivers probably also contain asbestos. This asbestos appears to come from erosion of natural deposits. It is likely to increase if mining operations resume in the Fortymile and Kobuk regions (as is being discussed by Native Corporations). If mining activities resume, EPA will need the data as a measure of "background" levels of asbestos to determine whether mining activities are polluting the rivers with additional amounts of asbestos.

### Cost-Effective Bio-Indicators of Marine Pollution

What biological manifestations of oil pollution stress are most suitable for use as indicators of ecosystem health in cold marine environments subjected to chronic pollution? This is a question of considerable importance to state and federal agencies responsible for the regulation of discharge of waste to the environment. This research is intended to identify those bio-indicator systems that offer both scientific validity and cost-effectiveness so that permits can be written that provide the environmental monitoring information society wants without putting unnecessary financial burdens on the discharger.

In order to meet these two objectives, a two-phased approach is necessary. Phase one includes a critical review of the scientific literature to determine which available bio-indicator systems are most likely to be useful in cold climates and a workshop at which environmental decision makers, industry representatives and research scientists can discuss the pros and cons of various bio-indicators. It is important that the literature search not simply be a computer-controlled retrieval of all work in the field, but a careful evaluation by scientists with the experience and ability to judge the applicability of the work to cold climates. Phase two consists of scientific research both in controlled laboratory experiments and in actual field discharge conditions to determine the statistical relationship between selected bio-indicator responses and petroleum exposure.

Biodegradation and Toxicity of Hydrocarbons in Oiled Waters

Current policy regulates the dumping of low molecular weight aromatic hydrocarbons into the Alaskan environment without knowing either how long they remain or what they form. Current research shows that these chemicals will accumulate in much the same way as DDT and PCB's do in the world ocean. In addition, it shows that entirely unsuspected partial oxidation products accumulate from aromatic hydrocarbon biodegradation similar to the conversion of DDT to DDE. Dissolved aromatic hydrocarbons are biodegraded at rates which give lifetimes of from weeks to many decades in Southcentral Alaska. By way of comparison, the lifetimes under similar conditions in the Gulf of Mexico are only a few days (unpublished observations). So, very long lifetimes for dissolved hydrocarbons in seawater are a cold-climate phenomenon.

The research approach is to 1) identify the organic products of dilute dissolved aromatic hydrocarbon biodegradation by indigenous Alaskan microflora, 2) quantify the portion of each component produced during attack by the organisms, 3) produce these components in quantity with radiolabels attached, 4) measure the decomposition rates of both these radiolabeled products and their parent hydrocarbons in potential receiving waters of Alaska, and 5) produce a model that forecasts concentrations of both the aromatic hydrocarbons and their products on an estuarine and global scale. Only with this kind of information can a reasonable regulatory policy be formulated.

Ecosystem Impacts of Placer Mining

The renewal of placer mining activity in Alaska has placed a developmental burden upon several of Alaska's streams and estuaries. Although the introduction of large amounts of suspended particulate matter is the most obvious of the resulting impacts, other potentially more serious perturbations may arise through less visible insults such as the introduction of heavy metals and large quantities of dissolved and particulate organic matter. These impacts could have either deleterious or positive impacts on stream biota depending upon whether additions were toxic (e.g., mobilized arsenic) or a potential food source to invertebrates (suspended peat particles). Very little information is available on stream ecosystem alteration by developmental impacts in Alaska and most permitting and regulatory action is based upon visible changes in water quality or criteria adopted from temperate latitudes bearing small relevance to the extreme seasonal hydrologic regimes of interior and arctic Alaska.

## Waste Disposal Research

The planning team made two major recommendations, one for a more intensive review of research needs and one for a research project that would complement an existing EPA project (Tilsworth, 1982).

### Review Cold-Climate Waste Research Needs

The planning team strongly recommended a more focused review and planning effort before funds were expended on field research. First, a comprehensive information review would be conducted and documented in an Information Report. The Information Report would be distributed in draft form to the confirmed program participants for review and comment. Following the incorporation of review comments and the examination of additional information sources identified by the reviewers, a final Information Report would be prepared and distributed to program participants. Within the next three months, participants would meet in an intensive workshop to discuss the Information Report and provide a consensus on research priorities.

### Effect of the Arctic Climate on Risk of Fecal Contamination

The specific research topic offered here, "Research Plan to Determine the Effect of the Arctic on Risk of Fecal Contamination," is a refinement of the research plan abstract recommended as highest priority during the Chena Hot Springs waste disposal presentation. It was selected as one area in which field and laboratory research can make a new and significant contribution to the existing body of knowledge. The contribution would be significant because it would provide information on the severity of a potentially serious health hazard, and because this research will provide decay coefficients which can be used to alter the design of waste treatment and disposal systems on a fairly site-specific basis for individual cold-regions communities. Such coefficients are used routinely in developing design criteria for waste treatment systems in temperate latitudes; they have not been developed for cold regions.

## Habitat Modification/Manipulation Research

Although a wide range of potential effects on habitat were considered and most of these will need to be addressed in coming years, only three of the specific problems discussed were ranked highly enough by workshop participants to warrant their inclusion in the initial program plan.

### Impact of Oil Development Upon Coastal Tundra Wetlands

Expanding oil and gas development in tundra wetlands of northern Alaska is a source of increasing environmental impact. In order to develop an environmentally sound management plan, three major research approaches are recommended for study of North Slope wetlands.

1. Carry out an extensive literature search and evaluation on the impact of oil development on coastal tundra. A great many studies have already been done in this area and the greatest initial contribution that this project could make would be a summary and evaluation of this work and a set of preliminary conclusions as to which habitats are most likely to be sensitive to environmental damage and which habitats are of particular biological importance.

This literature survey would involve contact with industry and agencies as well as a survey of the published literature.

2. Adopt a simplified habitat classification scheme of major types that are (a) biologically important and (b) readily recognizable from infrared aerial photography. Produce a guide for managers that would enable them to identify these habitats from aerial or ground photography or vegetation data and that would provide a ranking of habitat types in terms of biological importance and sensitivity to disturbance. These rankings would be developed in research approaches 1 and 3.

3. Determine the time course of impact of various environmental disturbances by comparing control areas with disturbed areas of different ages. Community response would be measured in terms of altered soil properties (temperature, thaw depth, pH, salt content, and nutrient availability), vegetation characteristics (species composition, primary production and biomass by species, plant nutrient content and pattern of phenological development), and use by mammals and waterfowl. Permanent plots would be established in each dated disturbance and followed by non-destructive sampling over a period of years to confirm that comparison of different-aged disturbances at one time is a valid measure of the time course of community recovery or degradation.

The results of this research program should have direct application to EPA's needs in Alaska. It is designed to provide a quick preliminary (2 year) and a final (5 year) managers' guide that will enable EPA or any other management agency concerned with tundra wetlands to define important wetland types and define sensitivity to various disturbances in each of the major wetland types. The manager can then make environmentally sound decisions on permit applications using the managers' environmental guide and either aerial or ground photography or minimal vegetation data.

Impact of Logging on Interior Alaskan Stream Ecosystems

The subarctic taiga environment of interior Alaska (between the Alaska Range to the south and the Brooks Range to the north) is among the least studied forest regions of the United States. Interior Alaska is a region of discontinuous permafrost and extensive forest interspersed with low-lying wetlands and above-treeline alpine tundra. This region has the potential for vastly accelerated development and exploitation, with conflicting management pressures already brought about by burgeoning population and volatile land ownership issues.

Quantitative, documented information of either undisturbed or managed subarctic upland landscapes and associated stream systems is extremely scarce. Agency response to state and federal land management and regulation directives, notably Section 208 of Public Law 92-500 (non-point source pollution), is hampered by the current lack of knowledge of both the permafrost-dominated taiga upland environments, and the response of that environment to resource management practices.

The study recommended here is designed to investigate specific impacts of timber harvest in interior Alaska's forests on headwater stream systems. This research would be best done at Caribou-Poker Creeks Research Watershed in central Alaska where the air quality group is recommending a major research

focus. The two groups could use many of the same logistic facilities and environmental information.

The primary "customers" for the knowledge to be gained in this research are natural resource managers operating in Alaska's subarctic, and the agencies/personnel having oversight and regulatory authority over both natural resources management and environmental protection. In Alaska, state regulatory agencies are currently attempting to exercise oversight on forest management operations, in accord with the 1978 Alaska Forest Practices Act. The agencies are handicapped in developing guidelines and "Best Mangement Practices," because of lack of quantitative documentation of the impacts of forest harvest on streams in the subarctic. The results of this research will provide sorely needed factual data on such effects. The results may substantiate current policy or indicate need for revision; in either case, the documentation is needed to help ensure that an appropriate level of environmental protection accompanies forest harvest in the taiga uplands.

### Gravel Removal from Riparian Habitats

Consideration of the need for habitat protection should begin with habitats that support an unusually diverse, abundant, or valuable biological resource and with habitats that are directly threatened by development activities. When these are found in a single habitat type, special attention is called for. This is the case for riparian habitats of the arctic slope of Alaska.

The recommended research approach would be to:

* utilize aerial photography and ground truthing to provide a classification and survey of riparian habitats of the arctic slope of Alaska, identifying those that are particularly productive, critical to animal populations or vulnerable to development, and

* establish an intensive study site along the Saganavirktok River, easily accessible from the Dalton Highway to:

    1) document the plant diversity, community structure, and productivity of representative riparian stands with respect to seasonal flooding and stage of riparian succession, and

    2) document the use of riparian communities by grazing vertebrates and nesting birds, and assess the importance of riparian communities to populations of these animals on the arctic slope of Alaska.

## Program Implementation

This report sets forth the conceptual framework and research plans for the high priority research areas detailed in Appendix A. It therefore provides the fundamental basis for implementation of the EPA Cold-Climate Environmental Research Program. The program will be under the direction of an EPA project officer and coordinated by PNL's project manager as advised by the two committees.

## Current Program Status

Following development of the research plans summarized above, an Agency Oversight Committee involving representatives from over 20 federal, state and local agencies was formed as an advisory body to the Cold-Climate Research Program. The purpose of the committee is to provide a mechanism for integrating research with the parallel efforts and interests of other agencies. This committee will meet at least once a year, prior to the generation of RFPs, to review and comment on the EPA's research plans for the coming year. This will enable program managers to consider new perspectives and accommodate needs and interests of other agencies in the actual conduct of research. In addition, where agency responsibilities overlap, particularly on problems too large to be addressed using single-agency resources, this committee serves as a focal point for joint or cooperative research efforts.

At its first meeting the Agency Oversight Committee, as a whole and in selected subgroups, utilized the computer-aided process to prioritize the research plans summarized above. The research on Vehicle Emissions and Alternate Fuels had already been implemented at the time of the meeting. Although all 17 of the remaining research plans are considered important, the priorities established by this committee are being used as the primary guidance in determining order of implementation. The plans expected to be implemented during the 1982 and 1983 fiscal years at a combined funding level of 600 to 1100K are as follows:

* Impact of Oil Development Upon Coastal Tundra Wetlands
* Ecosystem Impacts of Placer Mining
* Biodegradation and Toxicity of Hydrocarbons in Oiled Waters
* Urban Pollution - Pollutants and Health Effects
* Cost-Effective Bio-Indicators of Marine Pollution
* Asbestos Levels in Rural Alaskan Drinking Water
* Urban Pollution - Develop Basis for Predicting Pollutant Dispersion in Highly Stable Atmospheres
* Impact of Logging on Interior Alaskan Stream Ecosystems
* Gravel Removal From Riparian Habitats
* Summary and Synthesis of Cold-Climate Air Pollution

To ensure that resulting research would best meet all agency concerns, committee members have volunteered staff time and meeting facilities to assist in refining work statements before the work begins.

A second advisory group, the Technical Review Committee, helps select winning bidders responding to requests for proposals.

## ACKNOWLEDGEMENTS

This report represents the cooperative effort of a great many people in the Alaskan environmental science community. In particular, it was through the vision of Dr. Norman Glass, EPA Project Officer and Director of the Terrestrial Division, Environmental Research Laboratory, Corvallis, Oregon, that this project was undertaken. Once priority research needs had been identified, the research plans to fulfill those needs had to be developed by technical experts in the relevant scientific disciplines. This planning was done by a team from the University of Alaska, Fairbanks, Alaska, and Tetra Tech., Inc., Anchorage, Alaska. The University component of the team was coordinated by Dr. David Norton and Dr. Glenn Juday. Task leaders were Dr. Gunter Weller, air pollution; Dr. Don Button, water contamination/consumption; and Dr. Terry Chapin, habitat modification/manipulation. Dr. Robin Sener of Tetra Tech., Inc., coordinated research planning in the waste disposal area. Major contributors in the various fields were:

Air Pollution - Dr. Thomas Gosink
Dr. Glenn Shaw
Mr. Leonard Verrelli

Water Contamination/Consumption - Dr. Helen Myers
Dr. Don Schell
Dr. David Shaw
Mr. Douglas Redburn

Habitat Modification/Manipulation - Dr. Glenn Juday
Ms. Rosa Meehan
Dr. Mark Oswood
Dr. Charles Slaughter

Waste Management - Dr. Robin Sener

The project was managed by Dr. Jim States and coordinated by Sandra Henry from the Alaska Operations Office of the Pacific Northwest Laboratory, Battelle Memorial Institute.

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## INTRODUCTION

Since its inception, the Environmental Protection Agency has recognized that cold regions pose unique environmental problems. EPA operated a research laboratory in Fairbanks, Alaska for several years. More recently, the agency has funded cold-climate research through the Environmental Research Laboratory in Corvallis, Oregon. In recent years, the pace of natural resource development in Alaska has accelerated and concomitantly the range of potential environmental problems has broadened. Funds available for environmental research have not kept pace.

One result of the increased range of needed research and the relatively limited funding has been an ongoing debate about which research needs are most pressing and who should take the lead. The EPA program has been increasingly criticized by special interest groups, each having its own perspective on what EPA's research priorities should be. Although many of the criticisms were correspondingly biased, the Agency felt that the following were valid: 1) research priorities have been largely determined by a select group and have not been broadly representative of existing needs, 2) research projects have often failed to provide the information needed for solving specific environmental problems under EPA jurisdiction, 3) considerable past research has reflected principal investigator interests rather than EPA need to know, and 4) program planning on a year-to-year basis with little interagency coordination has resulted in the neglect of major environmental problems, particularly those requiring more than one year of research and more financial resources than the EPA alone could afford.

Consequently, in September of 1981, the EPA asked the Pacific Northwest Laboratory (PNL) of Battelle Memorial Institute, to develop a work plan for a three- to five-year program that would redress these deficiencies. Our approach was comprised of three phases. In the first phase we interviewed a large number of environmental scientists, environmental managers and natural resource developers who were conversant on a broad range of environmental problems. This selection process identified a group of informed and articulate individuals who represented an equally broad range of viewpoints. In the second phase we involved as many of these individuals as possible in an innovative process for prioritizing needed research. During the third phase, plans for priority research were developed in sufficient detail to allow contractors to begin work immediately. The resulting program plan is being implemented by PNL through its Alaska Operations Office as an on-site management contractor under supervision of an EPA project officer. The research will be performed by organizations experienced in cold-climate research and best qualified to do the work. Coordination and collaboration with other research institutes and agencies will occur on the larger problems where responsibilities overlap.

Workshops were conducted utilizing an innovative decision process to incorporate as much informed opinion as possible in achieving consensus while minimizing divisive debate. It is believed that this approach provides the broad conceptual framework and planning that are necessary to avoid repeated yearly disruptions of research due to political pressures from special interest groups. The objective was a three- to five-year program encompassing both short- and long-term research of high relevance to the EPA and cold regions that it serves.

## METHODS

Our intention was to select the highest priority research on the basis of the most current knowledge about natural resource developments and their possible effects on cold-climate environments. Such knowledge is available primarily from the people involved in such matters on a daily basis. Consequently, these people were the principal sources of information, beginning with their involvement in an extensive series of interviews, continuing through their assistance in three research prioritization workshops, and culminating with their review and comment on this report.

## INTERVIEWS AND SELECTION OF PARTICIPANTS

All interviews were conducted in person by Dr. States, the project manager. The initial list of interviewees was compiled from Battelle and EPA resources and augmented by suggestions from the interviewees themselves. The objective was to canvass experts from state and federal agencies, universities and private business. This, it was felt, would ensure representation from the widest possible range of environmental disciplines, resource developers and regulatory offices. Each interviewee was subjected to the following general line of questioning:

- In your area(s) of knowledge, which natural resource developments, existing or contemplated, are most problematic (likelihood of adverse environmental and health effects is high or uncertainty about this likelihood is high)?

- Among the problem areas identified, what kinds of research are most needed to enable us to circumvent or minimize the problems?

- In your opinion, which of these research problems should be EPA responsibilities?

- Are you aware of ongoing research or published reports which address these problem areas in detail?

- Are there other experts in your or related fields with whom we should talk?

Once the interviews had been completed, those interviewed or others they recommended became the pool from which we selected participants for the workshops in which research priorities would be decided. Criteria for selection included: standing among professional peers; cooperation and interest during discussions; availability; and ability to present, in an articulate manner, one or more of the groups or points of view encountered.

## WORKSHOP PROCESS FOR PRIORITIZING DECISION ALTERNATIVES

A portable, computer-aided decision process was developed by PNL specifically for this project. Its purpose was to enable a group of experts to simultaneously bring their subjective and objective knowledge to bear in identifying and ranking research options. The decision to use a computer-assisted approach resulted from our disillusionment with standard workshop methods in making good use of available expertise and in achieving a collaborative decision representative of the overall group. The

computer-assisted approach was applied three times on this project, first to identify and rank generic environmental research issues, second to identify and rank specific researchable problems under the higher priority generic issues, and third to prioritize detailed research plans. The approach followed in the workshops involves several steps:

## Developing Provisional Lists of Decision Options and Judgement Criteria

Based on information developed in the interview phase, the project staff develops a comprehensive provisional list of decision options along with a list of criteria by which the importance of these options should be judged. These two lists are discussed and amended by workshop participants to their collective satisfaction. Considerable information is exchanged, leading to a common information base for group decisions. During this initial phase, all suggested items are added to the provisional list without criticism or debate.

## Shortening the Lists

Workshop participants next reach a collective decision as to whether or not the lists of decison options and criteria are too long. Lists judged too long are shortened using agreed-upon "screens" for elimination. For example, generic research issues viewed as being under the jurisdiction of and adequately addressed by other agencies were eliminated from further consideration. In coming up with the final list of criteria it was necessary to keep in mind the following objectives: 1) keep the list as short as possible, 2) avoid overlap between criteria, and 3) cover the range of subjects that must be considered in prioritizing the decision alternatives.

## Weighting the Final List of Judgement Criteria

The selected criteria provide a common basis for judging the importance of decision options, in this case, environmental research options. Once we have a group of agreed-upon ranking criteria, the micro-computer is used to generate a list of the criteria in random pairs. Each participant "scores" the importance of the first member of each pair relative to the second member of the pair on a five-point scale. Pairing scores are entered into the computer where the "weight" of each criterion is calculated. The weights are a measure of the importance of a given judgement criterion relative to all the others and are used later in calculations which determine priority of decision options.

The paired comparison approach overcomes the inherent difficulties involved in making simultaneous comparisons among several criteria. Participants are required to indicate comparative importance between only two alternatives at any one time. All possible pairings are offered to ensure that each criterion is evaluated against every other criterion on the list. Randomization minimizes the possibility that weightings of the criteria would be influenced by the order of their treatment rather than intrinsic importance.

## Prioritizing Decision Alternatives

With a final list of decision alternatives and weighted judgement criteria in hand, the group is prepared for the definitive step in the workshop process, that of prioritizing the remaining decision options under consideration. It has been our experience that by this stage we have a very involved, very positive

group of participants. However, having arrived at the point of actually making a decision, they are also biased in defense of their own preferred alternatives. Left unchecked, this tendency can have negative consequences.

For this and a variety of other practical reasons, we use an Apple II micro-computer to generate score sheets on which each participant makes his own ranking judgements independently of the rest of the group. A separate score sheet is generated for each decision alternative. The decision alternative is printed across the top of the page with the judgement criteria listed below. Beside each criterion are printed the numerals 0-9 representing the degree to which the participant believes that criterion applies to the given decision alternative. Each participant receives a complete set of score sheets on which he ranks the importance of each decision alternative based on each of the criteria listed below it. Participants are asked to indicate "no reponse" for any item on which they feel unqualified to make a judgement (in order to avoid offsetting the valid judgements of those who are qualified). Resulting scores from all participants are then entered into the micro-computer which stores and processes the data.

Details of criteria pair randomization, data input, validation and editing will not be discussed here. In the discussion of computer functions to follow, assume a workshop of "A" participants using "B" criteria to rank "I" decision alternatives or issues.

Storage of Data for Weighting Judgement Criteria

Consider the three dimensional array X(a,b,c) where:

a = participant # (min = 1, max = A)

b = criterion # (min = 1, max = B)

c = criterion # (min = 1, max = B)

At each position of this array the computer stores a numeric value derived from each participant's evaluation of a pair of criteria, criterion-b vs. criterion-c. For the diagonal, where b=c, store a zero. Values stored in the array are shown in the following table.

| Evaluation | X(a,b,c) | X(a,b,c) |
|---|---|---|
| criterion-b << criterion-c | 0.0 | 1.0 |
| criterion-b < criterion-c | 0.25 | 0.75 |
| criterion-b = criterion-c | 0.5 | 0.5 |
| criterion-b > criterion-c | 0.75 | 0.25 |
| criterion-b >> criterion-c | 1.0 | 0.0 |
| remembering the diagonals where b=c | 0.0 | 0.0 |

Weighting Judgement Criteria

A weight for each judgement criterion may be computed for any specified group of participants ranging from the whole group down to one individual. The weight for criterion b is computed using all values stored in the

three-dimensional array, x, which correspond to participants included in the specified group.

$$W_b = \frac{\sum_{a=1}^{A} \sum_{c=1}^{B} A(a,b,c)}{\sum_{a=1}^{A} \sum_{b=1}^{B} \sum_{c=1}^{B} A(a,b,c)}$$

Where participant a must be coded as included in the current subset.

This weight for criterion b is then converted to a percent of all responses made by the specified group:

$$\%b = W_b \times 100$$

Storage of Data for Issue Ranking

Each participant will score each issue on a 0 to 9 scale for each criterion. Consider the three dimensional array X(i,a,b) where:

i = issue (min = 1, max = 1)

a = participant (min = 1, max = A)

b = criterion (min = 1, max = B)

The computer places the participant's scores in this array without modification; simply putting a value 0,1,2,3...., 8,9 in the proper location i,a,b.

Scoring the Issues

When calculating the issue score, the computer works only with the specified subset of participants and issues. That is, in computing the required sums, it omits those values in arrays x and y which correspond to excluded participants or issues.

The score for an issue is simply the sum of all included 0 to 9 responses for that issue multiplied by the group-determined weight for each criterion.

Thus the score $S_i$ is:

$$S_i = \sum_{a=1}^{A} \sum_{b=1}^{B} Y(i,a,b) * W_b$$

The score is a measure of the importance of that decision alternative in the judgement of the specified group of participants.

Ranking the Issues

Once the scores, $S_i$, are computed, they are sorted in descending order, indicating relative importance.

## Feedback Session

Results of the computer analysis are presented to participants in the final session of the workshop. Each participant is given an opportunity to comment on the results in light of all that has gone before. It is in this session that important dissenting views, which might otherwise be lost in the consensus process, are captured. Frequently, this is also the time when innovative ideas develop from the new perspective afforded by an overview of the results.

## Advantages of the Decision Process

The advantages offered by this process over standard workshop procedures may be summarized as follows:

* Maximizes Capture of Information: The process allows incorporation of the best subjective and objective knowledge and experience of every participant. It offers an opportunity for all participants to contribute both to the list of options and to the criteria by which their importance is judged, to clarify the options offered, and to express opinions both pro and con. Discussions leading up to final lists of weighted judgement criteria and options prove to be a valuable process of mutual education whereby a common information base is developed for sound group judgements.

* Minimizes Conflict: By providing each participant with an equal opportunity to express his or her views prior to preparing their individual scoresheets for the final ranking exercise, nonproductive and divisive debate is minimized.

* Achieves Consensus: The final, computerized result is a clear summary of the group judgement. Although an individual participant may not agree with that judgement, he recognizes that he has had an equal opportunity to influence it.

* Provides for In-Depth Analysis of Results: Computer tabulation of results provides for a better record and more thorough analysis of results than is possible under other presently accepted workshop procedures. In addition to analysis of group consensus, the process offers the option of analyzing the results by subgroupings such as disciplines, affiliations, or even individuals. The final computer printout offers in-depth information such as standard deviation (which provides a measure of the diversity of opinion on any given issue and allows insight into how agreement or disagreement is distributed among criteria).

* Provides Good Closure: Feedback and results are available during the process and final results are available to participants at the close of the workshop, thus enabling them to leave with a clear understanding of the outcome. The opportunity for each participant to comment on the result offers a satisfying sense of accomplishment and closure to the workshop and enables workshop leaders to capture important dissenting views that might otherwise be lost in a typical consensus report.

The workshop prioritization process had to be applied in two workshops because ranking criteria were different for generic issues than for specific researchable problems within issues. For example, elegance of experimental design can be applied as a criterion only when considering specific problems.

## RESEARCH PLANNING

Once the highest priority generic issues had been identified, a competitive RFP was issued soliciting bids in one or more of four research areas representing the four major routes of environmental effect: air pollution, water contamination/consumption, habitat modification/manipulation and waste disposal. The University of Alaska was selected in the first three categories and Tetra Tech., Inc was selected in the fourth.

These two organizations assisted with the development of specific research plans in two stages. First, following the initial workshop, they screened a large number of possible research problems under the highest priority generic issues. They then developed preliminary sketches for research on problems they deemed to be most important or research approaches that appeared most promising. These preliminary sketches were presented at the second workshop, added to by suggestions from reviewers and prioritized by the computer-aided decision process.

In the second phase of research planning, the subcontractors were asked to develop detailed research plans for as many of the highest priority preliminary sketches (or meaningful combinations thereof) as was possible within existing limits of time and resources. These plans were to be done according to the following format and general guidance:

### INTRODUCTION

* Clear statement of the problem(s) and/or question(s) to be addressed by the research
* Current state of knowledge and available literature
* Rationale and background information on need for the research, its relevance to environmental decision making and why it is of interest to the EPA
* Relationship to the rest of the research package and to the guidance provided by the two workshops.

### RESEARCH APPROACH

* Strategy for the proposed research, including identification of alternatives and arguments for selecting the proposed option
* Special characteristics of the approach that make it appealing from scientific and decision-making points of view
* Important aspects of experimental design to be addressed, include details of experimental design if sufficient information exists (or how this information should be obtained if not)
* Identification of study site alternatives, recommended sites and rationale

### RESEARCH MILESTONES

Each research project was to be defined in terms of a series of milestones recommended by the planning team, beginning with an indication of when the research should begin and why. As much as possible, milestones were defined in terms of identifiable outputs to which time and dollar estimates might be tied. The final milestone was to be an estimated time to completion (including final reports). Where the milestone was an output, the nature of that output was to be indicated.

### REQUIRED RESOURCES

* Manpower, time (in months) and dollars estimated for reaching each milestone
* Type of expertise and organizational qualifications required for succesful completion of the work
* Identification of specific organization and individuals having the qualifications to perform the work

### APPLICATION OF RESULTS

The ways in which findings of the research were expected to be applied in identifying and resolving environmental problems were to be clearly specified. Attempts were to be made to anticipate who might use the information, how it might be used, and the approach (formatting, presentation, politics) by which results of the research might be applied in protecting the environment. Statements were to indicate that if the answers to the questions posed could be obtained before the development activity commenced, the results might be applied beforehand to circumvent potential problems. The overall objective of the detailed planning process was to provide the pertinent information that an EPA contractor would need in order to start work immediately. Where the state of knowledge was so poorly developed that the specificity called for in the outline could not be provided, ways were to be suggested in which the uncertainties might be addressed and resolved creatively.

## RESULTS

This section presents the major results of each of the three project phases discussed above -- interviews, prioritization of generic issues and specific research problems and detailed research planning.

### INTERVIEWS

It is not possible to convey all that was learned in the extensive series of interviews. These interviews successfully produced the preliminary lists of generic research issues from which all else followed. The agencies, organizations, expertise and/or interests represented at the interviews are given in Table 1. To further ensure as broad a base as possible, an effort was made to include additional agencies, organizations and individuals in later phases of the work.

Table 1. Contacts Made as a Basis for Initial List of Cold-Climate Environmental Research Issues and Potential Workshop Participants.

| NAME | ORGANIZATION | POSITION OR EXPERTISE | LOCATION |
|---|---|---|---|
| | Business and Other | | |
| Wayne Hanson | ERTEC | Terrestrial Ecologist | Anchorage |
| Jim Hemming | Dames & Moore | Manager, Alaska Operations | Anchorage |
| Dick Firth | Woodward-Clyde Consultants | Vice President | Anchorage |
| Larry Rundquist | Woodward-Clyde Consultants | River Engineer | Anchorage |
| Mike Joyce | Woodward-Clyde Consultants | Staff Biologist | Anchorage |
| Ihor Lysyj | Rockwell International, Inc. | Marine Biologist | Newbury Park, CA |
| Russell Babcock | Bear Creek Mining Company | Vice President | Anchorage |
| Rick Shafer | Sohio | Manager, Environmental Affairs | Anchorage |
| Scott Robertson | Atlantic Richfield Company | Senior Environmental Coordinator | Anchorage |
| G. Scott Ronzio | Atlantic Richfield Company | Senior Environmental Coordinator | Anchorage |
| Walt Parker | Parker and Associates | President and Transportation/ Telecommunications Consultant | Anchorage |
| Chris Noah | Alaska Council on Science & Technology | Executive Director | Juneau |
| Dick Mikkelson | Alyeska Pipeline Company | Environmental Coordinator | Anchorage |
| Dennis Prediville | Alyeska Pipeline Company | Government Affairs Supervisor | Anchorage |
| Marc Lorenzen | Tetra Tech., Inc. | Vice President | Seattle |
| Melissa Strom | Alaska Conservation Foundation | Executive Secretary | Anchorage |
| | State Agencies and Municipalities | | |
| Jim Anderson | Alaska Department of Natural Resources | Director, Technology Transfer | Anchorage |
| Ken Hudson | Alaska Department of Natural Resources | Div. of Minerals and Energy Management | Anchorage |
| Greg Daggett | Alaska Department of Natural Resources | Div. of Land and Water Management | Anchorage |
| Meg Hayes | Alaska Department of Natural Resources | Div. of Land and Water Management | Anchorage |
| Pete Authier | Alaska Department of Natural Resources | Div. of Forestry | Anchorage |
| Marco Pignalberi | Doyon Limited, Native Corporation | President | Fairbanks |
| Phil Derrien | Doyon Limited, Native Corporation | Biologist | Fairbanks |
| Dick Eakins | Division of Industrial Development | Director | Juneau |
| James Souby | Division of Policy Development and Planning | Director | Juneau |
| Gretchen Keiser | Division of Policy Development and Planning | Coordinator, Oil and Gas Leasing | Juneau |
| Ernst Mueller | Alaska Department of Environmental Conservation | Director | Juneau |

Table 1 (Page 2)

| NAME | ORGANIZATION | POSITION OR EXPERTISE | LOCATION |
|---|---|---|---|
| Glenn Akins | Alaska Department of Environmental Conservation | Assistant Director | Juneau |
| Bill Lamoreaux | Alaska Department of Environmental Conservation | Coordinator, Anchorage Distrist Office | Anchorage |
| John Halterman | Alaska Department of Environmental Conservation | Director, Program Division | Juneau |
| Leonard Verrelli | Alaska Department of Environmental Conservation | Air Quality Program, Supervisor | Juneau |
| Douglas Redburn | Alaska Department of Environmental Conservation | Oceanographer, Environmental Assessment | Juneau |
| Dave Sturdevant | Alaska Department of Environmental Conservation | Terrestrial Habitat Protection | Juneau |
| Tony Burns | Municipality of Anchorage | Municipal Planner, Remote Sensing | Anchorage |
| | **Universities** | | |
| David Hickok | Alaska Environmental Information and Data Center, Alaska Council on Science and Technology | Director | Anchorage |
| | | Director | Anchorage |
| Larry Underwood | Alaska Environmental Information and Data Center | Physiological Ecologist | Anchorage |
| Don Button | University of Alaska, Institute of Marine Sciences | Environmental Chemist | Fairbanks |
| John Bligh | University of Alaska, Institute of Arctic Biology | Chairman | Fairbanks |
| Glenn Juday | University of Alaska, Institute of Northern Forestry | Ecological Reserves Coordinator | Fairbanks |
| Dave Norton | University of Alaska, Geophysical Institute | Ecologist | Fairbanks |
| Neil Davis | University of Alaska, Geophysical Institute | Meterology/Seismology | Fairbanks |
| Robert Weeden | University of Alaska, Resource Management | Natural Resources Managment | Fairbanks |
| Robert Carlson | University of Alaska, Institute of Water Resources | Engineer, Hydrologist | Fairbanks |
| Vim Wright | University of Washington, School of Environmental Studies | Acting Director | Seattle |
| Ostello Leopold | University of Washington, Quaternary Research Center | Director | Seattle |
| A. Lincoln Washburn | University of Washington, Quaternary Research Center | Chairman, Polar Research Board NAS | Seattle |
| N. Untersteiner | University of Washington, Quaternary Research Center | Director, Polar Research Center | Seattle |
| Larry Bliss | University of Washington, Botany Department | Chairman | Seattle |
| | **Federal Agencies** | | |
| Calvin Lensink | U.S. Fish and Wildlife Service | Project Leader, Marine Birds | Anchorage |
| Bill Palmisano | U.S. Fish and Wildlife Service | Director of Research | Anchorage |
| John Morrison | U.S. Fish and Wildlife Service | Special Studies Group Leader | Anchorage |
| Keith Bayha | U.S. Fish and Wildlife Service | Director, Habitat Preseravtion | Anchorage |
| Ray Corning | U.S. Fish and Wildlife Service | Analyst, Habitat Preservation | Anchorage |
| Earl Kari | U.S. EPA - Pipeline Inspectors Office | Director, Environmental Studies | Anchorage |
| Robert Courson | U.S. EPA - Region X Headquarters | Director, Technical Services | Seattle |

Table 1 (Page 3)

| NAME | ORGANIZATION | POSITION OR EXPERTISE | LOCATION |
|---|---|---|---|
| Jim Sweeney | U.S. EPA, Alaska Operations Office | Director | Anchorage |
| Ray Morris | U.S. EPA, Alaska Operations Office | Chief, Oil and Special Materials | Anchorage |
| Norman Glass | U.S. EPA - Corvallis Environmental Research Lab | Director, Terrestrial Division | Corvallis |
| Dick Tindall | U.S. Bureau of Land Management | District Office Director | Anchorage |
| Dick Vermimen | U.S. Bureau of Land Management | District Office Associate Director | Anchorage |
| Art Hosteman | U.S. Bureau of Land Management | Chief, Biological Resources | Anchorage |
| Jim Johnson | U.S. Bureau of Land Management | Chief, Division of Resources | Anchorage |
| Bill Gabriel | U.S. Bureau of Land Management | Special Studies Group Leader, State Office | Anchorage |
| Terry McFadden | Cold Regions Research and Engineering Laboratory | Chief, Alaska Projects Office | Ft. Wainwright |
| Max Brewer | U.S. Geological Survey | Operations Chief, AK Petroleum Reserves | Anchorage |
| John Haugh | U.S. Geological Survey | Biologist | Reston, VA |
| Leslie Vierick | U.S. Forest Service | Ecologist | Fairbanks |

## GENERIC ENVIRONMENTAL ISSUES

The task set for this project in recommending what the EPA might include in its Cold-Climate Environmental Research Program was not a simple one. At the beginning we wanted to treat the subject broadly enough to include the entire range of environmental issues potentially associated with natural resource development. Then, by some logical process that incorporated existing knowledge on cold-climate environmental research needs, we wanted to focus on the relatively few problems most appropriate for concentrated EPA attention. Finally we wanted to select a very few "straws" out of the "haystack" of potential environmental problems from which to develop detailed research plans and experimental designs for EPA cold-climate research.

### Workshop Participants

Participants in the initial workshop were selected to represent as wide a range of opinions on cold-climate research needs as possible (Table 2). Individuals from several EPA offices, including the Alaskan Field Office and the Office of Research and Development, were present to help focus on research that fell under EPA's mission and mandates. There were also representatives from other federal and state agencies, major resource developers, environmental consultants, and university experts representing major environmental disciplines.

### Broad Range of Issues

Early in the planning effort, it was perceived that the level at which environmental issues were defined must somehow be standardized. When an expert was asked for his list of high-priority issues, the response almost invariably ranged through a continuum from very generic (effects of oil and gas development on marine ecosystems) to very specific (effects of aromatic hydrocarbons on species A in Valdez Harbor). Any attempt to prioritize a list of issues ranging through this continuum is a feat of mental gymnastics and tends to favor those issues we know most about. In addition, the very generic issues encompass too many potential research problems while at the very specific level there are too many research problems to list, much less prioritize.

To minimize these difficulties, we first defined environmental issues at an intermediate level of specificity. The resulting level remained well above the level at which one would normally attempt to develop experimental designs. We therefore designated them "generic environmental issues." They were characterized in terms of five principal aspects:

* the natural resource development being considered
* the stages or phases of development being considered
* principal routes through which environmental effects may be transmitted
* major environmental effects for which concern has been expressed
* important geographic, climatic or other physical/environmental variables to be considered.

The first three components describe the development activity aspects of an issue (development type, development phase and route for environmental effect), thus providing a common level of issue definition. The last two components

TABLE 2. Participants in Workshop to Prioritize Generic, Cold-Climate Environmental Research Issues.

| NAME | ORGANIZATION | POSITION OR EXPERTISE | LOCATION |
|---|---|---|---|
| Larry Bliss | University of Washington, Botany Dept. | Chairman | Seattle |
| Charles Boddy | Usibelli Mining Company | Director of Reclamation | Usibelli |
| Raymond Corning | U.S. Fish and Wildlife Service | Habitat Protection | Anchorage |
| Ray Dronenburg | North Slope Borough | Science Coordinator | Barrow |
| Al Galli | U.S. EPA - Environmental Processes and Effects Research | EPA Mission and Mandate | Wash. D.C. |
| Norman Glass | U.S. EPA - Corvallis Research Lab | Director, Terrestrial Division | Corvallis |
| Ray Hadley | University of Alaska - Institute of Marine Science | Assistant Director | Fairbanks |
| Jim Hemming | Dames & Moore | Manager, Alaska Operations | Anchorage |
| Larry Johnson | University of Alaska & Cold-Regions Research & Engineering Lab | Plant Ecologist | Fairbanks |
| Ronald Johnson | University of Alaska - Mechanical Engineering | Water Pollution Control Technology | Fairbanks |
| Ron Kreizenbeck | EPA - Region 10 Office | Appointed to Direct Alaska Operations | Seattle |
| Dick Mikkelson | Alyeska Pipeline Company | Environment | Anchorage |
| Ray Morris | Marine Consultants | Marine Biologist | Anchorage |
| David Norton | University of Alaska - Geophysical Institute | OCS Project Biologist | Fairbanks |
| Douglas Redburn | Alaska Department of Environmental Conservation | Oceanographer, Environmental Assessment | Juneau |
| Scott Robertson | ARCO Alaska, Inc. | Senior Environmental Coordinator | Anchorage |
| Mary Ann Simmons | Pacific Northwest Laboratory | Statistics and Computer Programming | Richland |
| Jim States | Pacific Northwest Laboratory | Project Leader | Richland |
| Kimbal Sundberg | Alaska Department of Fish and Game | Habitat Protection | Anchorage |
| Leonard Verrelli | Alaska Department of Environmental Conservation | Air Quality Program Supervisor | Juneau |

describe the "problem" aspect of the issue. For the purposes of this project, then, an environmental issue was any natural resource development activity for which we might anticipate significant environmental problems.

Workshop participants considered 120 natural resource development activities that could potentially affect the environment (States 1982, Appendix E). The activities were grouped under seven major types of natural resource development and a cumulative effects category:

1. Nonfuel Minerals
2. Oil and Gas
3. Coal
4. Electrical Power Generation
5. Renewable Resource Utilization - Fisheries
6. Renewable Resource Utilization - Timber
7. Renewable Resource Utilization - Agriculture
8. Cumulative and/or Regional Effects

Each of the seven major types of natural resource development were subdivided into four or five stages or phases of development (such as extraction, processing, product transport and storage, accidents and associated population/infrastructure development). These, in turn, were subdivided into four principal routes through which effects might be transmitted: air emissions, water contamination/consumption, habitat modification/removal and waste disposal. This exercise ultimately yielded 120 natural resource development activities.

These 120 activities were either ranked or were screened out during the three-day workshop. Elimination was by one or more of the following screening criteria:

* failure to identify significant environmental problems potentially associated with the development activity

* potential problems were identified but considered relatively unimportant

* identified problems were not germane to EPA mission or mandates

* the issue is being adequately addressed by other organizations

## Issue Priorities

Eighty-two of the 120 items were eliminated. Seventeen experts participated in ranking the remaining 38 issues, using the computer-aided process described in the Methods section of this report. In addition to listing the 38 issues in order of priority there are two other ways to look at the workshop results (States, 1982). First, the issues can be ranked as to how the expressions of environmental concern were distributed among major development types. By this approach, oil and gas development accounted for over half of all concerns expressed by workshop participants. A second way to analyze the results is in terms of the major "route" of environmental effect. The greatest concerns, expressed in descending order, were for water contamination/consumption, air emissions, waste disposal, and habitat

modification/removal. A large, natural break in weighted scores below issue 15 was conveniently used to further shorten the 38 issue list. Elimination was necessary because funds for environmental research are limited. These are the top 15 issues on which research should be focused:

1. Effects of oil and gas processing (including petrochemicals) through air emissions
2. Cumulative and/or regional effects through air emissions
3. Cumulative and/or regional effects through water contamination/consumption
4. Effect of oil and gas accidents through habitat modification
5. Cumulative and/or regional effects through habitat modification/removal
6. Effects of oil and gas product transport and storage through habitat modification/removal
7. Cumulative and/or regional effects through waste disposal
8. Effects of nonfuel mineral extraction through habitat modification/removal
9. Effects of oil and gas processing (include petrochemicals) through waste disposal
10. Effects of oil and gas processing (include petrochemicals) through water contamination/consumption
11. Effects of nonfuel mineral extraction through water contamination/consumption
12. Effects of electrical generation operations (all types) through air emissions
13. Effects of oil and gas support-population/infrastructure through air emissions
14. Effect of oil and gas accidents through water contamination/consumption
15. Effects of oil and gas extraction through water contamination/consumption.

Although the list is organized by priority, research is usually organized under disciplines. Therefore, the list was reorganized and categorized based on routes of environmental effect (Table 3), which more adequately reflects usual disciplines or areas of scientific research. Detailed research plans were developed for selected problems in the four routes of effect and under the 15 issues within those routes. Attention was given to each issue to the degree suggested by its priority ranking. Cumulative and/or regional effects are special problems requiring greater resources than are available to the EPA alone. The approaches or strategies for dealing with these problems will be

TABLE 3. Environmental "Route" Categories Encompassing the Top 15 Issues

| Route | Issue Development Type | Activity | Rank |
|---|---|---|---|
| Water Contamination/ Consumption | Cumulative/Regional Effects | All | 3 |
| | Oil and Gas | Processing | 10 |
| | | Accidents | 14 |
| | | Extraction | 15 |
| | Nonfuel minerals | Extraction | 11 |
| Air Emissions | Cumulative/Regional Effects | All | 2 |
| | Oil and Gas | Processing | 1 |
| | | Support Population/ Infrastructure | 13 |
| | Electrical Power | Operations | 12 |
| Waste Disposal | Cumulative/Regional Effects | All | 7 |
| | Oil and Gas development | Processing | 9 |
| Habitat Modification/ Removal | Cumulative/Regional Effects | All | 5 |
| | Oil and Gas | Accidents | 4 |
| | | Product Transport/ Storage | 6 |
| | Nonfuel Minerals | Extraction | 8 |

addressed during the course of the program through joint funding and cooperative agreements with other agencies and organizations.

## SPECIFIC RESEARCH PROBLEMS

The above-described process of reducing the number of generic environmental issues from 200 to 15 provided a relatively narrow range of topics within which the project team could identify researchable questions or problems and select a few of these for sketching out possible research. This was accomplished in the following steps:

* A comprehensive list of candidate problems was developed under the four major routes for effects (air pollution, water contamination/consumption, habitat modification/removal and waste disposal).

* Experts prepared preliminary research sketches for as many of the candidate problems as possible.

* Sketches were reviewed and modified by the project team in cooperation with the Alaska Department of Environmental Conservation, the state agency whose local perspective was most like that of the EPA.

* The modified list of preliminary sketches was presented at a second workshop. Invited reviewers had received the list of candidates prior to the workshop and were asked to come prepared to add their own suggestions. The combined list of sketches was then prioritized using the computer-aided decision process.

### Workshop Participants

A second workshop was convened to select the very highest priority research problems for detailed research planning. Participants were of two types. One group consisted of a combined team from the four task groups (air pollution, water contamination/consumption, habitat manipulation/modification and waste disposal) and the Alaska Department of Environmental Conservation. This first group had developed the preliminary sketches. The other group consisted of invited reviewers. Participants in this group were selected on the basis of their 1) having participated in the earlier workshop, thereby providing both expertise and continuity to the second workshop, 2) having been recommended by project task leaders as able to bring particularly pertinent technical knowledge into the review process, and 3) being representatives of other agencies or organizations having environmental responsibilities but not having been previously involved in the project. A list of participants is given in Table 4.

### Broad Range of Problems

Distribution of the 15 high-priority generic issues into four task areas provided the focus for identifying specific problems in each area. The task leader and a team of experts discussed each problem set extensively before selecting the top candidates for recommendation to the project team as a whole. For example, the waste disposal team evaluated 25 potential problems of which only five were retained for discussions with the rest of the planning group. Although it is not possible to discuss all of the candidate problems considered,

TABLE 4. Participants in Workshop to Prioritize Specific Cold-Climate Research Topics That Were Identified Under High-Priority Generic Issues.

| NAME | ORGANIZATION | POSITION, EXPERTISE OR GROUP | LOCATION |
|---|---|---|---|
| Don Button | University of Alaska, Institute of Marine Sciences | Environmental Chemist | Fairbanks |
| Terry Chapin | University of Alaska | Habitat | Fairbanks |
| Norman Glass | U.S. EPA - Corvallis Environmental Research Lab | Director, Terrestrial Division | Corvallis |
| Tom Gosink | University of Alaska | Air Pollution | Fairbanks |
| Larry Johnson | University of Alaska & Cold-Regions Research & Engineering Lab | Plant Ecologist | Fairbanks |
| Ronald Johnson | University of Alaska - Mechanical Engineering | Water Pollution Control Technology | Fairbanks |
| Glenn Juday | University of Alaska, Institute of Northern Forestry | Habitat | Fairbanks |
| Glenn Shaw | University of Alaska, Geophysical Institute | Air Pollution | Fairbanks |
| Deborah Kirk | Alaska Department of Environmental Conservation | Air Pollution | Juneau |
| Rosa Meehan | U.S. Fish & Wildlife Service | Habitat | Fairbanks |
| Ted Merrell | National Marine Fisheries Laboratory | Marine Pollution | Auke Bay |
| Helen Myers | University of Alaska, WAMI Medical Education Program | Human Health | Fairbanks |
| David Norton | University of Alaska, Geophysical Institute | Coordinator | Fairbanks |
| Walt Pearson | Battelle Marine Research Laboratory | Marine Pollution | Sequim, WA |
| Ken Rahn | University of Rhode Island, Graduate School of Oceanography | Air Pollution | Narragansett, RI |
| Douglas Redburn | Alaska Department of Environmental Conservation | Oceanographer, Environmental Assessment | Juneau |
| Scott Robertson | ARCO Alaska, Inc. | Senior Environmental Coordinator | Anchorage |
| Don Schell | University of Alaska, Institute of Water Resources | Water Pollution | Fairbanks |
| Robert Sener | Tetra Tech., Inc. | Waste Disposal | Anchorage |
| David Shaw | University of Alaska, Institute of Marine Science | Marine Pollution | Fairbanks |
| Charles Slaughter | U.S. Forest Service | Habitat | Fairbanks |
| Kimbal Sundberg | Alaska Department of Fish & Game | Habitat Protection | Anchorage |
| Steve Sparrow | University of Alaska, Agricultural Experiment Station | Habitat/Agriculture | Fairbanks |
| James Sweeney | Environmental Protection Agency, Alaska Operations | Air Pollution | Anchorage |
| Leonard Verrelli | Alaska Department of Environmental Conservation | Air Pollution | Juneau |
| Patrick Webber | University of Colorado, Institute of Arctic Alpine Research | Plant Ecology | Boulder, CO |
| Jim States | Battelle Alaska Operations | Project Leader | Anchorage |
| Gunter Weller | University of Alaska, Geophysical Institute | Air Pollution | Fairbanks |
| Dick Williams | Alaska Department of Environmental Conservation | Waste Disposal | Fairbanks |
| Carol Lewis | University of Alaska, Agricultural Experiment Station | Habitat/Agriculture | Fairbanks |
| Carl Amstrup | Alaska Agricultural Action Council | Executive Director, Habitat/Agriculture | Fairbanks |

a list of the 25 waste disposal topics and reasons for their acceptance or rejection are given in Tables 5 and 6, respectively.

In a meeting of project coordinators, task leaders, several representatives from the Alaska Department of Environmental Conservation and a representative from the U.S. Fish and Wildlife Service, the overall list of candidates for research planning was reduced to 42. Although much shorter than the initial list, it was still much too long for all to be included in the EPA program. Hence, the need for convening a second prioritization workshop. Prior to the workshop, preliminary sketches for the required research were written to provide sufficient information on objectives, scope, timing and costs for well-reasoned comparisons.

## Problem Priorities

At the workshop, seven more candidate problems were added to the list, bringing the total number to 49. These 49 were presented, discussed and prioritized, using the computer-aided decision process. Results are shown for candidate problems in each of the four research areas plus the group of topics added in the workshop (Table 7). The rank of each candidate is given for the workshop as a whole and then for subgroups defined by scientific discipline or affiliation. The numbers in parentheses at the end of each topic title refer to a numbered preliminary sketch in Appendix B.

## Synthesis

The research prioritization exercise was necessarily a reductionist approach, beginning with the wide range of generic environmental issues associated with natural resource development and ending with only a few discrete research tasks of the highest priority. Research planning team members were strongly convinced, however, that the research planning process (as opposed to the prioritization process) should produce an integrated, implementable research package directed towards answering relevant, high-priority questions. To that end the planning team was asked to pay particular attention to the following advice offered by participants in the final workshop feedback session:

* Consider combining several research problems by identifying regions and specific sites where research which integrates a number of the high-priority research tasks might be undertaken.

* Develop, if possible, detailed research plans on one or more of the higher priority research topics in each of the four categories, thereby offering a program that is comprehensive as well as focused on the most important problems.

* Provide a mix of basic and applied, long- and short-term studies.

* Seek opportunities for cooperation and collaboration with other agencies so as to cover as many of the priority research topics as possible within given funding limitations.

The research plans developed by the planning team are presented in the following section.

TABLE 5. Waste Disposal Topics Recommended for Inclusion in Research Prioritization Workshop.

| WASTE DISPOSAL TOPIC | REASON FOR INCLUSION |
|---|---|
| 1. Cost-Effective Waste Treatment and Disposal Alternatives for Rural Alaskan Communities | o Inappropriate, outmoded procedures in effect at most communities.<br>o Wastes persist and accumulate yearly in cold climates.<br>o No integrated program exists to provide practical solutions. |
| 2. Small-Scale Treatment Technologies for On-Site Greywater Disposal in Permafrost Soils | o Septic tanks and leach fields inefficient in permafrost areas.<br>o Alternative cold-climate sewage treatment systems exclude greywater from treatment.<br>o Greywater often dumped untreated around residences or facilities.<br>o Yet greywater treatment is required by State of Alaska regulations, creating a regulatory dilemma.<br>o No cost-effective solution has been identified for single-residence or single-family use. |
| 3. Solid Waste Generation Rates and Predictive Model for Rural Alaska | o No available information exists on waste generation rates for rural Alaskan communities.<br>o This lack of knowledge limits agency ability to develop effective waste management and resource recovery procedures.<br>o Results will allow projection of disposal site life expectancies and enable realistic planning and design of new sites. |
| 4. Effect of Arctic Climate on Solid and Liquid Waste Decomposition | o No data available for arctic conditions.<br>o Wastes persist and accumulate year after year at disposal sites.<br>o We need to know if certain wastes should be disposed of differently in cold climates, and how to do so efficiently. |
| 5. Freeze-Thaw Cycle Effects on Concentration and Migration of Contaminants at Disposal Sites and Settling Ponds | o At disposal sites and settling ponds, the yearly freeze-thaw cycle may produce zone concentration of contaminants in far greater concentration than the waste stream.<br>o Innovative design features can avoid build-up of heavy metals or other contaminants in bottom sludge at these sites. |

TABLE 6. Waste Disposal Topics Not Recommended for Inclusion in Research Prioritization Workshop.

| WASTE DISPOSAL TOPICS | REASONS FOR PROVISIONAL EXCLUSION |
|---|---|
| 1. Control of Arsenic Contamination from Mine Tailings | o Site-specific, case-by-case monitoring and mitigation will be conducted by industry and agencies. |
| 2. PCB Waste Management in Alaska: Associated Problems and State-of-the-Art Procedures | o Agency concensus that this is not a current problem. |
| 3. Restoration of Hazardous Waste Sites and Spill-Damaged Areas | o Funding should be provided by private sector. |
| 4. A Community (Small and Rural) Model for Handling Hazardous Material Transportation Emergencies | o Not sufficiently research oriented. |
| 5. Innovative Technologies to Detect Waste Plume Movements in Multimedia Environments | o Agency need not demonstrated for Alaska. |
| 6. Landfill Design for Permafrost Soils | o Integrated into "Cost-Effective Waste Treatment and Disposal Alternatives for Rural Alaskan Communities." |
| 7. Acid Mine Drainage | o Site-specific, case-by-case monitoring and mitigation will be conducted. |
| 8. Effects of Acidity from Snowmelt | o Review comments indicate low priority. |
| 9. Spray Atomization of Wastewater at Remote or Mobile Camp Facilities | o ADEC may investigate this possibility in-house. |
| 10. Oceanic Disposal of Non-Hazardous Solid Wastes | o Application probably not practical for small communities. |
| 11. Alternative Technologies for Disposal of Seafood Processing Wastes | o Brown and Caldwell study now in progress. |
| 12. Control of Suspended Fines from Offshore Dredging and Artificial Island Construction | o Energy and mining industries giving attention to this problem through privately funded studies. |

(Table 6 continued)

| WASTE DISPOSAL TOPICS | REASONS FOR PROVISIONAL EXCLUSION |
|---|---|
| 13. Processing of Metalliferous Gravels and Muds at Offshore or Coastal Facilities | o Activities are subject to agency monitoring. |
| 14. Effects of Suspended Drilling Mud Components and Dissolved Additives on Marine Plakton | o Energy industry giving attention to this problem through privately funded studies. |
| 15. Optimum Offshore Disposal Techniques for Drilling Mud, Cuttings, and Conditioners | o Energy industry giving attention to this problem through privately funded studies. |
| 16. Control of Leachate Runnoff from Highly Mineralized Mine Tailings | o Private industry and agency monitoring programs will be available. |
| 17. Putrescible Waste Management at Remote Camps | o Technology available; increased compliance enforcement required. |
| 18. Gas Turbine Stack Injection of Liquid Waste | o Now under study by Northwest Alaskan Pipeline Company and ADEC. |
| 19. Effects of Waste Disposal on Pathogen Distribution in Lakes and Lagoons | o Transferred to Water Quality Group for review. |
| 20. Restoration of Settling Ponds and Reserve Pits Following Mining or Drilling | o More appropriate for industry-funded programs. |

Table 7. Results of Environmental Research Prioritization Workshop at Chena Hot Springs, Fairbanks, Alaska, March 30 - April 2, 1982. Shown are the relative rankings for 49 research topics considered by all workshop participants and by subgroupings of those participants according to scientific discipline or agency affiliation.

| | Topic Number and Title (Rank) | All Participants (n = 28) | Discipline | | | | | Affiliation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Air (6) | Habitat (8) | Water (6) | Waste (2) | Other (6) | Agency (9) | University (14) | Consultant (3) | DEC (4) | EPA (2) | FWS & FG (2) |
| Air Pollution | 1. Air Pollution -- Define Problem -- Literature Survey (1) | 29 | 43 | 11 | 31 | 30 | 8 | 40 | 17 | 34 | 46 | 17 | 34 |
| | 2. Air Pollution -- Sources and Transport -- Dispersion from Local Pollution -- Added Tracers (2A) | 3 | 7 | 7 | 6 | 8 | 19 | 8 | 7 | 4 | ?? | 40 | 11 |
| | 3. Air Pollution -- Sources and Transport -- Dispersion from Local Pollution -- Natural Tracers (2B) | 33 | 23 | 38 | 14 | 12 | 40 | 34 | 29 | 22 | 33 | 34 | 24 |
| | 4. Air Pollution -- Sources and Transport -- Dispersion from Local Pollution -- Downwash of Stack Effluents (2C) | 7 | 6 | 26 | 11 | 31 | 1 | 2 | 23 | 35 | 3 | 2 | 30 |
| | 5. Air Pollution -- Sources and Transport -- Dispersion from Local Pollution -- Meteorological Prediction of High CO Days (2D) | 2 | 3 | 13 | 15 | 9 | 6 | 1 | 21 | 23 | 2 | 4 | 6 |
| | 6. Air Pollution -- Sources and Transport -- Intermediate and Long Range Transport -- Industrial Pollutants (3A) | 13 | 9 | 28 | 17 | 26 | 12 | 14 | 12 | 24 | 16 | 20 | 36 |
| | 7. Air Pollution -- Sources and Transport -- Intermediate and Long Range Transport -- Imported Pollutants (3B) | 4 | 13 | 15 | 1 | 27 | 5 | 20 | 1 | 12 | 21 | 8 | 28 |
| | 8. Air Pollution -- Chemistry -- Urban and Industrial -- Priority Pollutants (4A) | 1 | 1 | 4 | 12 | 5 | 9 | 3 | 3 | 5 | 1 | 28 | 8 |
| | 9. Air Pollution -- Chemistry -- Urban and Industrial -- Pollutant Photochemistry (4B) | 17 | 4 | 23 | 28 | 16 | 30 | 9 | 26 | 25 | 4 | 42 | 18 |
| | 10. Air Pollution -- Chemistry -- Urban and Industrial -- Pollutant Deposition (4C) | 9 | 2 | 18 | 32 | 23 | 18 | 7 | 22 | 31 | 5 | 19 | 29 |
| | 11. Air Pollution -- Chemistry -- Background Levels -- Natural (4D) | 21 | 8 | 24 | 34 | 35 | 27 | 24 | 20 | 33 | 20 | 45 | 23 |
| | 12. Air Pollution -- Chemistry -- Secondary Pollutants (4E) | 32 | 12 | 34 | 38 | 28 | 36 | 32 | 30 | 14 | 19 | 48 | 31 |
| | 13. Air Pollution -- Effects -- Ames Mutagenicity Tests (5A) | 38 | 22 | 42 | 40 | 15 | 39 | 39 | 39 | 15 | 31 | 39 | 38 |
| | 14. Air Pollution -- Effects -- Health Effects -- Respirable Particles (5B) | 8 | 10 | 30 | 7 | 2 | 17 | 12 | 16 | 9 | 9 | 36 | 32 |
| | 15. Air Pollution -- Effects -- pH -- Acid, Alkaline Precipitation (6) | 19 | 5 | 36 | 10 | 43 | 24 | 21 | 41 | 41 | 15 | 33 | 41 |
| | 16. Air Pollution -- Migitative Measures -- CO Reduction by Alternate Fuels (7A) | 16 | 14 | 29 | 21 | 11 | 3 | 5 | 32 | 21 | 12 | 3 | 2 |
| | 17. Air Pollution -- Migitative Measures -- Vehicle Use Studies (7B) | 5 | 11 | 12 | 5 | 21 | 4 | 4 | 19 | 16 | 10 | 9 | 1 |
| | 18. Air Pollution -- Synthesis of Cold Climate Air Pollution (8) | 10 | 41 | 2 | 19 | 33 | 7 | 26 | 5 | 19 | 41 | 12 | 4 |
| Habitat Modification | 19. Habitat Modification -- Forest Management and Aquatic Habitats (1) | 23 | 28 | 10 | 13 | 29 | 33 | 33 | 11 | 10 | 27 | 27 | 35 |
| | 20. Habitat Modification -- Gravel Removal from Riparian Habitats (2) | 26 | 34 | 6 | 30 | 18 | 29 | 31 | 15 | 11 | 35 | 16 | 17 |
| | 21. Habitat Modification -- Oil Develpoment in Coastal Tundra Wetlands (3) | 15 | 32 | 1 | 24 | 36 | 23 | 16 | 6 | 32 | 29 | 5 | 3 |
| | 22. Habitat Modification -- Environmental Optimization of Transportation Corridors (4) | 35 | 36 | 20 | 37 | 20 | 32 | 37 | 24 | 13 | 37 | 13 | 30 |
| | 23. Habitat Modification -- Damage Assessment and Migitation of Oil Spills (5) | 34 | 24 | 22 | 45 | 42 | 16 | 30 | 31 | 26 | 24 | 22 | 37 |
| | 24. Habitat Modification -- Agricultural Land Clearing and Migratory Birds (8) | 49 | 49 | 49 | 48 | 49 | 48 | 49 | 48 | 48 | 49 | 49 | 48 |

(continued)

Table 7 (continued)

| | Topic Number and Title (Rank) | All Participants (n = 28) | Discipline | | | | | Affiliation | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Air (6) | Habitat (8) | Water (6) | Waste (2) | Other (6) | Agency (9) | University (14) | Consultant (3) | DEC (4) | EPA (2) | FWS & FG (2) |
| Water Contamination | 25. Water Contamination -- Ecosystem Impacts of Placer Mining (1) | 14 | 25 | 3 | 23 | 32 | 13 | 13 | 13 | 20 | 23 | 6 | 5 |
| | 26. Water Contamination -- Control of Sediment Discharge (2) | 37 | 45 | 32 | 27 | 44 | 26 | 36 | 38 | 29 | 39 | 15 | 21 |
| | 27. Water Contamination -- Peat Mining Effect on Aquatic Ecosystems (3) | 27 | 35 | 9 | 9 | 22 | 43 | 35 | 10 | 42 | 40 | 21 | 19 |
| | 28. Water Contamination -- Dissolved Hydrocarbons -- Concentrations (4A) | 24 | 30 | 21 | 16 | 17 | 22 | 27 | 13 | 40 | 26 | 23 | 27 |
| | 29. Water Contamination -- Dissolved Hydrocarbons -- Biodegradation (4B) | 22 | 40 | 16 | 8 | 14 | 20 | 28 | 9 | 37 | 38 | 24 | 15 |
| | 30. Water Contamination -- Dissolved Hydrocarbons -- Excreted Products (4C) | 30 | 42 | 15 | 18 | 25 | 37 | 44 | 2 | 38 | 47 | 35 | 42 |
| | 31. Water Contamination -- Dissolved Hydrocarbons -- Chronic Effects on Algae (4D) | 41 | 27 | 39 | 39 | 37 | 44 | 43 | 25 | 45 | 30 | 36 | 47 |
| | 32. Water Contamination -- Petroleum Pollution in Oil Brine and Waters off North Slope (5) | 31 | 44 | 37 | 2 | 3 | 21 | 17 | 27 | 43 | 25 | 7 | 10 |
| | 33. Water Contamination -- Innovative Biomonitoring -- Literature Review and Field Evaluation (6) | 11 | 19 | 5 | 29 | 24 | 10 | 15 | 8 | 17 | 17 | 25 | 9 |
| | 34. Water Contamination -- Sublethal Toxicity of Produced Waters (7) | 18 | 17 | 40 | 3 | 4 | 14 | 10 | 28 | 27 | 11 | 11 | 12 |
| | 35. Water Contamination -- Literature Survey, Environmental Effects of Chronic Industrial Discharges (8A) | 39 | 36 | 31 | 46 | 34 | 31 | 25 | 44 | 30 | 22 | 26 | 7 |
| | 36. Water Contamination -- Herbicide Effects and Stream Eutrophication from Farming (10, 11) | 43 | 37 | 33 | 47 | 41 | 42 | 46 | 37 | 36 | 42 | 44 | 44 |
| | 37. Water Contamination -- Development of Northern Lakes Water Quality Model (12) | 44 | 29 | 45 | 42 | 38 | 45 | 41 | 43 | 44 | 36 | 30 | 22 |
| Waste | 38. Waste -- Cost-Effective Waste Treatment and Disposal Alternatives for Rural Alaskan Communities (1) | 12 | 16 | 19 | 20 | 3 | 11 | 6 | 35 | 3 | 6 | 14 | 16 |
| | 39. Waste -- Small Scale Treatment Technologies for On-Site Graywater Disposal in Permafrost Soils (2) | 20 | 21 | 25 | 22 | 7 | 15 | 11 | 33 | 8 | 14 | 10 | 26 |
| | 40. Waste -- Solid Waste Generation Rates and Predictive Model for Rural Alaska (3) | 36 | 18 | 43 | 43 | 1 | 35 | 22 | 45 | 6 | 8 | 29 | 43 |
| | 41. Waste -- Effect of Arctic Climate on Waste Decomposition (4) | 28 | 20 | 27 | 33 | 6 | 25 | 19 | 41 | 1 | 13 | 18 | 39 |
| | 42. Waste -- Freeze-Thaw Cycle Effects on Contaminant Behavior at Disposal Sites (5) | 25 | 15 | 17 | 36 | 10 | 38 | 23 | 36 | 2 | 18 | 32 | 25 |
| Other | 43. Other -- Asbestos Levels in Rural Alaskan Drinking Water (1) | 6 | 26 | 8 | 4 | 19 | 2 | 18 | 4 | 7 | 28 | 1 | 14 |
| | 44. Other -- sediment Contamination in Cold Climate Aquatic and Marine Systems (2) | 40 | 39 | 41 | 25 | 47 | 34 | 29 | 40 | 39 | 43 | 31 | 33 |
| | 45. Other -- Litter/Detritus Degradation as a Measure of Ecosystem Function (3) | 46 | 31 | 46 | 35 | 48 | 41 | 42 | 47 | 28 | 45 | 37 | 46 |
| | 46. Salmon Carcasses as Source of Nutrients in Arctic Freshwater Systems (4) | 48 | 48 | 48 | 49 | 39 | 49 | 45 | 49 | 49 | 32 | 47 | 40 |
| | 47. Semi-Mobile Research Support Facility (5) | 45 | 46 | 44 | 41 | 40 | 28 | 47 | 42 | 18 | 48 | 41 | 45 |
| | 48. Research Reserves (6) | 47 | 47 | 47 | 44 | 46 | 47 | 48 | 46 | 46 | 44 | 46 | 49 |
| | 49. Water Contamination -- Oil Development Impact on Seagrass Ecosystems (6) | 42 | 33 | 35 | 26 | 45 | 46 | 38 | 34 | 47 | 34 | 43 | 13 |

## COLD-CLIMATE RESEARCH PROGRAM

The project team selected several from among the 49 research problems to be developed as detailed research plans. In making their selections, task leaders were asked to consider the advice (above) from the workshop feedback session; consider the prioritization results, particularly emphasizing those research topics which had been highly rated by 1) the overall group, 2) the experts in that particular research area, and 3) the EPA and/or the Alaska Department of Environmental Conservation (Table 7); and to use their best professional judgement in modifying and synthesizing topics where it seemed advisable. Consequently, there is not a one-to-one relationship between research topics offered at the workshop and research plans developed by the planning team. These research plans, provided in Appendix A, were submitted to Battelle by Tetra Tech., Inc. and the University of Alaska. Appendix A was prepared as a comprehensive five-year research program; all research plans included are considered to be of high priority for initiating or continuing research in the near-term. The resulting 17 plans are numbered and summarized below in four research categories (Air Pollution, Water Contamination/Consumption, Habitat Modification/ Manipulation and Waste Disposal). An additional plan on vehicle emissions was included later as a completion of ongoing research on carbon monoxide problems. Numbered research plans were prioritized by a multi-agency oversight committee (see Current Program Status section).

### Air Pollution Research

In general, air pollution topics received the highest priorities for environmental research. This is attributed to: 1) the fact that many of the pollution topics are existing problems rather than potential problems, 2) the potential for an airborne problem to be a geographically widespread problem, and 3) the potential for direct and indirect effects on human health.

The nature and severity of cold-climate air pollution problems may best be investigated in Alaska. The high Alaskan latitude produces extremes in temperature, solar radiation and inversion strengths not typical of the 48 contiguous states. Alaska's geography and topography present at least three distinct air pollution regions: the north slope, the interior and south-central Alaska. Each of these presents unique problems.

The current state of knowledge about air pollution in Alaska is incomplete and available information is widely scattered in the scientific literature. There is some information for a limited number of priority pollutants in urban areas, but such information is missing or is proprietary for the Prudhoe Bay area, and for pristine areas. Weather and climate information is generally available but health-related information is essentially nonexistent. Only general health criteria can be applied to what is known about the concentrations of a limited number of urban pollutants such as carbon monoxide and lead. Standard dispersion terms for modeling studies are not applicable to the extremely stable inversion conditions of the Interior. There has been some research in this area in the past year or so, but it needs to be completed. Data on respirable particles is generally restricted to the mass of the particles and virtually nothing is known about their size and number distribution or of the toxic components they may carry anywhere in Alaska. Although photochemical pollution has been theoretically predicted and has been

observed at similar latitudes in Europe, it has not been experimentally demonstrated in Alaska. Acid precipitation may be a threat to tundra regions of the north, particularly in light of increased industrial effluents in that area. Nothing is known about the current air pollution inputs, let alone projected future inputs. The phenomenon of "arctic haze" has recently received attention, but its sources, transport pathways and chemistry are far from well-known, and the potential effects on Alaska are likewise unknown. In short, there is relatively little information on air pollution in Alaska.

The State is an ideal air pollution research laboratory because the anthropogenic pollution sources are quite isolated and can be readily studied. It also offers a unique range of environmental conditions. In some respects the winter pollution problem in interior cities, such as Fairbanks, represents one extreme of the air pollution spectrum in the United States (Figure 2). In spite of Alaska's uniqueness, applications of the knowledge to be gained from air pollution projects recommended here will not be limited to Alaska. Well over half of the population of the United States is located in areas where the average monthly temperature is $0^{o}C$ or colder for at least one month out of the year.

Air pollution research was organized into nine basic projects or tasks under five categories:

Urban Pollution

1. a study of pollutants, especially particulate matter, in Alaskan urban centers and their human health effects

2. using observed CO and artificial tracer concentrations to predict dispersion of air pollutants under stable atmospheric conditions

3. Fairbanks transportation system characterization

4. mobile environmental test facility (METFAC) and alternate fuels studies to resolve cold-climate CO problems (note - METFAC studies were included after the preparation of Appendix A and therefore do not appear there)

Photochemistry

5. investigation of photochemistry at $65^{o}$ N latitude

Industrial Pollution

6. industrial air pollutant downwash and deposition and their potential effects (acid precipitation)

Background or Baseline Air Quality

7. concentrations, composition and transport of pollutants contributing to "arctic haze"

8. natural concentrations of organic and inorganic compounds

Figure 2.

SPECTRUM OF AIR POLLUTION SETTINGS

| | Fairbanks - Winter<br>Low Temperature<br>Icefog/Pollution | Los Angeles - Summer<br>Smog |
|---|---|---|
| Temperature | | 10°C/100m (Above Ground) |
| Temp Inversions | 30°C/100m (Surface) | |
| Radiation | None during winter<br>(~980 W $m^{-2}$ at the summer solstice) | High (>1000 W $m^{-2}$) |
| Saturation Vapor Pressure | Low (0.05 mb at -50°C) | High (42.43 mb at 30°C) |
| Chemistry | Non-oxidizing atmosphere<br>No photochemical reaction<br>"Wet" air chemistry<br>(Low absolute water content<br>but condensed form present) | Oxidizing atmosphere<br>Max. photochemical reaction<br>"Dry" air chemistry<br>(High absolute water content<br>but condensed form absent) |

Synthesis

9. summary and comparison of the existing state of knowledge on cold-climate air pollution -- before and after completion of the 5-year research program.

Urban Pollution -- Pollutants and Health Effects

The area of second highest concern in urban areas was the potential for deleterious health effects from airborne particles, especially from woodsmoke and vehicular emissions in different particle size ranges, particularly the respirable size range. Research objectives are to observe the time and space distribution of pollutants in Alaskan urban centers and assess their possible health effects. Investigators will use standard techniques for the collection and analysis of samples. Calibrated monitoring devices will be used for determinations of carbon monoxide, hydrocarbons, oxides of sulfur, nitrogen (including ammonia) and ozone at selected locations within Anchorage and Fairbanks. High volume samplers with a 10μ cutoff will be used to collect particle samples for mass loading, trace element and PAH analyses and toxicity screening studies. Size and number distribution of particles will be determined by means of diffusion batteries, aerosol spectrometers, etc. Health implications will be determined in two ways. One is to compare observed concentrations with recommended levels. The other is to perform Ames mutagenicity and phagocyte tests to ascertain synergistic effects.

Urban Pollution -- Develop Basis for Predicting Pollutant Dispersion in Highly Stable Atmospheres

This study is in two phases. Phase I is the final step in a project already underway which examines actual meteorological conditions during high CO days in urban centers in Alaska. The objective is to determine from actual case studies the type of meteorological conditions that cause CO concentrations in urban areas to increase. These data are being used to develop and calibrate a statistical model for predicting periods of high CO concentration. This is required for developing counter-measures and contingency plans for use during periods of high pollution.

Phase II involves the use of an artificial tracer, sulfur hexafluoride ($SF_6$) to determine empirically the dispersion equations that apply to the stable atmospheric conditions in the arctic and subarctic atmospheres. The result will be a modified Gaussian gas/particle dispersion equation which, unlike the presently used equation, is applicable to the highly stable atmospheric conditions in Alaska.

Urban Pollution -- Transportation System Characterization Study

This study is designed to test, by actual observation, the validity of several assumptions in the Fairbanks North Star Borough Air Quality Attainment Plan. These assumptions have been made regarding:

1. current average vehicle occupancy rates at
   a) downtown vs. area-wide traffic
   b) commuter vs. non-commuter vehicles
   c) various temperatures

2. vehicle idling for unattended vehicles and for attended vehicles prior to being driven

3. emissions during idling vs. each segment of the driving cycle

4. projections of conversion to diesel vehicles in the future.

Urban Pollution -- Vehicle Emissions and Alternate Fuels (Currently Underway)

The deepest concern expressed in the research prioritization workshop was about the potential effects of air pollutants on human health. The most immediate problem in this category is presented by two non-attainment areas (Anchorage and Fairbanks) where the EPA carbon monoxide (CO) standard has been repeatedly exceeded. These areas must be brought into compliance by 1987. Consequently, the Mobile Environmental Test Facility (METFac), now on loan to the Alaska Department of Environmental Conservation (DEC) from the EPA, is being used to conduct vehicle emission tests under low temperature conditions. This will enable the DEC and EPA to quantify the effectiveness of alternative transportation control strategies in achieving ambient air quality standards by the statutory deadline. Resulting information is expected to be useful to other cold-weather CO non-attainment areas in determining the most cost-effective ways to achieve emission reductions.

The work will consist of the following tasks:

1 - Complete an alternative fuels test program to determine the emission reduction benefits when using gasohol, compressed and liquified natural gas, etc., at low temperatures.

2 - Evaluate new state-of-the-art retrofit devices in terms of their effectiveness in reducing low temperature emissions.

3 - Collect test data to augment existing data base for emissions factor "splitting factors." This splitting technique is an analytical device that allows isolation of low temperature emissions generated during the initial startup and ensuing 2-6 minute warmup known as the cold start period. Additionally, it allows emissions from the mobile-phase of the operation to be separated from stationary-phase emissions. This allows both stationary and mobile emissions to be more accurately assigned to off-highway and on-highway use. This task also includes development of emission factor splitting programs which will address the effects of the cold-start, long-idle period to be used on the present EPA mobile 2.5 air quality model.

4 - Test selected vehicles before and after tune-ups to determine the effectiveness of tune-ups in reducing cold-start emissions. These tests will be limited to vehicles selected to augment data collected in the winter of 1981-82.

5 - Compare emissions from the standard driving cycle used in the Federal Test Procedure and an Alaska specific driving cycle.

6 - Retest vehicles participating in the 1981-82 METFac program to determine their emissions and fuel economy characteristics after twelve months of usage.

7 - Develop a final report analyzing the results of the above tests and describing the most promising alternatives for meeting carbon monoxide air quality standards by 1987.

Photochemistry at High Latitudes

Ozone and photochemical irritant production are of primary concern to the EPA mission. There is evidence that assumptions regarding the lack of photochemical reactions at high latitudes may not be correct, particularly during long summer days. The urban and industrial centers of Alaska are growing, yet virtually nothing is known experimentally about photochemical activity at high latitudes (above $60^{o}$ N) anywhere in the world.

Observations of ultraviolet radiation intensity, and organic and ozone concentrations at high latitudes ($65\text{-}72^{o}$ N) in urban (Fairbanks) and industrial (Prudhoe) areas will be used to ascertain the probable duration and intensity of photochemical reactions at high latitudes.

Industrial Studies - Pollution Downwash and Deposition Modeling

Recent air quality dispersion modeling of gaseous pollutants emitted from gas turbines has indicated that typical climatic conditions exhibited on the North Slope of Alaska may result in downwash of these pollutants to the ground at a relatively short distance from the point of emission. Several site-specific parameters, some of which cannot be adequately simulated by the current model, control the occurrence, relative frequency and magnitude of the downwash events. As a result of the downwash activity, pollutants contained in the turbine exhaust plume may reach the surface at a higher concentration than would normally be expected because of the limited plume transport time. The frequency of this downwash phenomenon may result in a much greater impact than previously projected on the health of resident workers and terrestrial and aquatic ecosystems on the North Slope.

Regulations for the emission of oxides of sulfur and of nitrogen are concerned only with concentrations in the air at any given time or averaged for a set period of time. The wind velocities of the North Slope are generally high, thus regulations are unlikely to be violated, yet substantial acid-producing material may be emitted. It is anticipated that the best manner in which to assess the occurrence, frequency and magnitude of downwash is to simulate climatic conditions, turbine exhaust plumes, and facility parameters in a series of wind tunnel experiments. These experiments are to assess the plume downwash phenomena for two discrete facility scaler models subjected to a variety of wind speeds, facility orientation and barometric pressures as a basis for a predictive model.

Field sampling to verify and improve the model, particularly for the North Slope areas, will require extensive use of aircraft throughout the year. Some analyses, eg., $NO_x$, $SO_x$, hydrocarbons, particulate counts, ozone, etc., will be made from the aircraft while flying downwind of facilities such as the Prudhoe Bay complex. Aircraft will also be required to pick up samples of snow, and wet and dry precipitation across the tundra. Battery-driven samplers which open only during snow or rain are commercially available, and will operate at low temperatures. Trace element data from background studies will also be employed along with pH and major anion/cation (ion chromatography) and trace gas data collected as a part of this project.

The primary output of this study will be a predictive computer model and associated software for the stack downwash under wet and dry conditions for distances up to 100 miles in the Prudhoe area. Such a model is critically necessary to provide source term input for aquatic and terrestrial models of potential effects from acid precipitation.

Background Studies - "Arctic Haze"

Industrial aerosols and emitted gases enter dry Eurasian air masses north of the polar front and travel over continental pathways into the high arctic regions. During transport, the aerosol removal rate is small due to the inherent stability of arctic air masses and the low amount of cloud volume available for scavenging. Such polluted arctic air masses reach the American Arctic and travel southward into Alaska, bringing with them residues that are characteristic of mesoscale air pollution of the kind that reaches and affects geographical areas far from emission sources (eg., the Canadian or Scandinavian acid rain problem). They are liable to prove more important in causing ecological damage than specific pollutant mixtures near source areas because they affect large areas and because they contain acid aerosol which has converted from sulfur-bearing trace gases.

The purpose of these studies is to assess the concentration, composition and transport pathways of trace gases and particles imported into Alaska from Eurasia and Northeastern U.S.A. The arctic and interior Alaskan air environment with superimposed arctic haze traveling in from specific source regions in eastern Europe and the central USSR provides a pristine laboratory system to study long-range transport of pollutant material. Trace aerosol chemical analyses will permit analysis of chemical signatures from distant source regions such as North America, Eastern Europe and the central Soviet Union.

The determination of chemical tracers should be performed with a minimum time resolution of 2-3 days to differentiate air mass alterations. In addition, the size distribution of particles in the range of particle radii $r>0.001$ is needed to assess the rate of conversion of gases to particles. Measurements should be carried out at an uncontaminated sampling site in interior Alaska.

Background Studies - Natural Concentrations of Organic and Inorganic Compounds

Organic constituents in clean air over the tundra have been determined in the past, before any Prudhoe Bay activity, to be over 0.20 ppm during the summer. This is a significant fraction of the recommended limits of hydrocarbons. It is nearly equal to the once-a-year, three-hour concentration guideline of 0.24 ppm of hydrocarbons in urban air. Some of the questions are, how extensive is the phenomenon in the Arctic and Subarctic, in area and in time? Are these organic compounds of the type that will induce photochemical activity?

Nature produces organic materials from marshy areas (eg., tundra). Past reports indicate organic sulfur compounds in the air can become quite concentrated in these areas, especially during summer when the potential for photochemical oxidation is also highest. These compounds, in turn, may be oxidized to produce oxides of sulfur and eventually sulfuric acid downwind of its point of origin. These natural components may be partly responsible for arctic haze phenomena due to oxidation and photochemical activity.

The objectives of this study are to determine what natural concentrations of organic and inorganic compounds arrive at industrial and urban sites in the Arctic and Subarctic. In some cases, this is an important fraction of the pollutant load that would normally be associated with human activity. Samples will be collected at two clean-air sites, upwind from an industrial site near Point Barrow and upwind from the Fairbanks urban center, to be compared to samples taken from within and downwind of these locations. Samples will be analyzed by gas chromotography, mass spectrography and special analyses for natural sulfur compounds.

Summary and Synthesis of Cold-Climate Air Pollution

At the beginning of the project there is a need to compile a synthesis of all available information on air pollution in Alaska. This is to include sources of pollutants, chemical characteristics, transport, effects of the pollutants and mitigative measures taken to date. Towards the end of the project a companion synthesis should be performed. This should be an assessment of the air pollution potential and problems for the entire State. The literature search should include available literature and reports from EPA, DEC, the University of Alaska and other institutions. The purpose is not so much to produce a systematic, computerized list of references as to offer a synthesis of the available information including foreign sources. The product will be two reports with comprehensive bibliographies. These up-to-date summaries should allow EPA (and DEC, municipalities, etc.) to:

a. plan future studies, since data gaps will be pointed out in the reports (particularly the first one)

b. update literature and research progress reports

c. plan mitigative measures to reduce pollution problems (control standards, siting of industry, routing of traffic, etc.).

Water Contamination/Consumption Research

Water-borne pollution is second only to airborne pollution in its potential for wide geographic dispersal and effects upon man, both direct and indirect. Hence, water-borne problems received considerable attention in the workshops.

Asbestos Levels in Alaskan Drinking Water

Asbestos is a carcinogen. Exposure can occur from inhalation and/or ingestion (Becklake, 1976; Selikoff, 1980). The amount of asbestos in the Yukon River, 40 - 1,000x$10^6$ fibers/liter, reaches a level higher than that associated with an increased risk of developing cancer from ingestion (Millette, 1981; Kaparek, 1980). Exposure in the region of the Yukon could occur not only from drinking the river water, but also from eating asbestos-laden fish from the river as well as inhalation of wind-blown dust from river banks and alluvial deposits in the region around the river.

The level at which asbestos can be considered hazardous has not been well established, particularly for ingested asbestos. In establishing standards of hazardous chemicals, the EPA has considered that development of pathological

conditions can arise from multiple factors acting together synergistically. If so, certain segments of the population may be at greater risk than others. Such a situation may exist in a region in rural Alaska where hepatitis B viral infection is endemic; this region includes villages on the lower Yukon and Kuskokwim Rivers. The lower Yukon contains high levels of asbestos; the Kuskokwim, judging from the geology of the watershed and initial measurements, probably does not. A liver cancer, primary hepatocellular carcinoma (PHC), is a common sequella of hepatitis B infection, but it is thought that another carcinogenic agent such as asbestos must be present for the cancer to develop. Although the population along the Kuskokwim River is greater, no cases of PHC have been diagnosed in people born in this region, whereas eight cases have been diagnosed in the lower Yukon population. (Four of these cases showed positive signs of previous viral infection, one case was negative and three were untested.)

It is not possible, within the scope of this research project, to definitively address the question of whether ingested asbestos could be acting as a cocarcinogen with hepatitis B virus in the development of PHC. Nevertheless, the assumption on which such a hypothesis might be based, i.e. that the asbestos content of drinking water in villages along the Yukon is higher than in the drinking water of villages along the Kuskokwim, can be tested. For this purpose, samples should be taken within the area of endemic hepatitis B viral infection. Villages to be chosen should be selected on the basis of size (Bethel on the Kuskokwim is a major population center), percentage of the population showing signs of hepatitis B viral infection, and the number of cases of PHC that appeared in the village (for villages on the Yukon). In addition, there have been cases of PHC in people born in villages outside the area of endemic hepatitis B infection. The villages of Noatak, Selawik, and Fort Yukon occur in areas where waterborne asbestos is predicted to be high. Conversely, there are cases of PHC on and near the Seward Peninsula where there is little evidence of asbestos formation. Any water sampling done in these regions should specifically test those villages where the PHC patients were born.

This research is directed towards determining the concentration of asbestos in selected Alaskan rivers and in the other drinking water sources to estimate the extent of exposure of the village populations to asbestos. The data on the levels of asbestos in the rivers and other drinking water sources will indicate to what extent hazardous amounts of asbestos are present. Should hazardous amounts of asbestos in fact be found, the data could be taken to appropriate state agencies to indicate the need for 1) testing of water supplies in villages not examined by this survey, 2) an educational campaign to alert rural residents to the danger of drinking water containing asbestos, and 3) the development of filters for asbestos which can be used in an innovative way where a public, piped water supply may not be the main source of water.

A preliminary survey of Alaskan geology and asbestos mining claims indicates that other rivers probably also contain asbestos. This asbestos appears to come from erosion of natural deposits. It is likely to increase if mining operations resume in the Fortymile and Kobuk regions (as is being discussed by Native Corporations). If mining activities resume, EPA will need the data as a measure of "background" levels of asbestos to determine whether mining activities are polluting the rivers with additional amounts of asbestos. The data on the amounts of asbestos in the drinking water in relationship to the development of PHC will be examined for consistency with the hypothesis that

asbestos can act as a cocarcinogen with hepatitis B virus. Definitive proof will have to be sought through the use of animal models or examination of a larger population exposed to both asbestos and hepatitis B virus.

## Cost-Effective Bio-Indicators of Marine Pollution

What biological manifestations of oil pollution stress are most suitable for use as indicators of ecosystem health in cold marine environments subjected to chronic pollution? This is a question of considerable importance to state and federal agencies responsible for the regulation of discharge of waste to the environment. This research is intended to identify those bio-indicator systems that offer both scientific validity and cost-effectiveness so that permits can be written that provide the environmental monitoring information society wants without putting unnecessary financial burdens on the discharger.

In order to meet these two objectives, a two-phased approach is necessary. Phase one includes a critical review of the scientific literature to determine which available bio-indicator systems are most likely to be useful in cold climates and a workshop at which environmental decision makers, industry representatives and research scientists can discuss the pros and cons of various bio-indicators. It is important that the literature search not simply be a computer-controlled retrieval of all work in the field, but a careful evaluation by scientists with the experience and ability to judge the applicability of the work to cold climates. Phase two consists of scientific research both in controlled laboratory experiments and in actual field discharge conditions to determine the statistical relationship between selected bio-indicator responses and petroleum exposure.

Laboratory results would be validated in the field by examining the indicator response along known petroleum pollution gradients resulting from chronic discharge in the marine environment. In Alaska such field gradients could include Port Valdez, where tanker ballast with residual petroleum is discharged; Cook Inlet, where co-produced water is discharged by offshore oil production platforms; and Prudhoe Bay, where co-produced water may be discharged in the future. Laboratory experiments should include oil-in-seawater preparations simulating direct releases, ballast water and co-produced water.

## Biodegradation and Toxicity of Hydrocarbons in Oiled Waters

Current policy regulates the dumping of low molecular weight aromatic hydrocarbons into the Alaskan environment without knowing either how long they remain or what they form. Current research shows that these chemicals will accumulate in much the same way as DDT and PCBs do in the world ocean. In addition, it shows that entirely unsuspected partial oxidation products accumulate from aromatic hydrocarbon biodegradation similar to the conversion of DDT to DDE. Dissolved aromatic hydrocarbons are biodegraded at rates which give lifetimes of from weeks to many decades in Southcentral Alaska. By way of comparison, the lifetimes under similar conditions in the Gulf of Mexico are only a few days (unpublished observations). So, very long lifetimes for dissolved hydrocarbons in seawater are a cold-climate phenomenon.

Substantial quantities of dissolved aromatic hydrocarbons, 2.4 metric tons per month, are now discharged into Port Valdez on a continuous basis. Additional amounts are likely to be included with the "produced" water that is separated from oil and discharged into the Beaufort Sea, and major accidental

releases remain a possibilty. Need for the research is based on observations showing that about half of the large amounts of aromatic hydrocarbons dumped into Alaskan waters are converted to peculiar organic products of unknown identity. Although these products disappear as invisible components of seawater, given the potentially very long lifetimes, the suggestive toxicity data, and the very large amount of material involved, it is entirely appropriate to identify what we are adding (present and potential) to the ocean. Since toxicity is associated with both the aromatic hydrocarbons and their oxidation products (clearly demonstrated for certain oxygenated derivatives), it is important to understand the lifetimes (biodegradation rates) of both the hydrocarbons and their products so that accumulation processes over decades and centuries can be considered. These data are critical to informed decisions on the adequacy of current processing of oily waste water, transportation accidents, and the consequences of increased dumping.

Current key questions are 1) how long do these aromatic hydrocarbons remain in the water column, 2) what concentrations are attained, 3) what significant organic products are formed during biodegradation, 4) what are the lifetimes of these biodegradation products in the environment, and 5) what is the toxicology of the resulting mixture?

The research approach is to 1) identify the organic products of dilute dissolved aromatic hydrocarbon biodegradation by indigenous Alaskan microflora, 2) quantify the portion of each component produced during attack by the organisms, 3) produce these components in quantity with radiolabels attached, 4) measure the decomposition rates of both these radiolabeled products and their parent hydrocarbons in potential receiving waters of Alaska, and 5) produce a model that forecasts concentrations of both the aromatic hydrocarbons and their products on an estuarine and global scale. Only with this kind of information can a reasonable regulatory policy be formulated.

Ecosystem Impacts of Placer Mining

The renewal of placer mining activity in Alaska has placed a developmental burden upon several of Alaska's streams and estuaries. Although the introduction of large amounts of suspended particulate matter is the most obvious of the resulting impacts, other potentially more serious perturbations may arise through less visible insults such as the introduction of heavy metals and large quantities of dissolved and particulate organic matter. These impacts could have either deleterious or positive impacts on stream biota depending upon whether additions were toxic (e.g., mobilized arsenic) or a potential food source to invertebrates (suspended peat particles). Very little information is available on stream ecosystem alteration by developmental impacts in Alaska and most permitting and regulatory action is based upon visible changes in water quality or criteria adopted from temperate latitudes bearing small relevance to the extreme seasonal hydrologic regimes of interior and arctic Alaska.

This research project would approach the problem from an ecological perspective. Selected indicator species of apical or near-apical position in the foodwebs of the impacted streams would be assessed as to potential impact in a "downward-looking matrix" to predict the likely points of stress on the life cycle or food supply or reproductive requirements of the organisms. These sensitive points would then be studied to see if, indeed, the perturbations were stressing the organisms. Thus, in an "adaptive environmental assessment," the focus of the study may shift rather than being committed to studying

predetermined perturbations which may have little real impact on the biota while more serious problems arising from indirect or less visible effects go unattended. A small group of interdisciplinary scientists would be assembled to address the consequence of mining activities. Biological and physical disciplines would be represented by the scientists most knowledgeable of the processes and environment of the area. Participation by mining industry personnel and agency personnel would aid in evaluating likely mining activity and possible control measures. For this project, either the Alaska Gold Company's working dredge in the Nome district or the Goodnews Bay platinum dredging in southwestern Alaska are likely candidates for study.

Activities of the interdisciplinary team of experts would be coordinated by a project manager and synthesized through a series of workshops. The environmental and biological data obtained would assist state and federal agencies in evaluating the magnitude of impacts and to realistically regulate human activity with an awareness of the ecological costs involved.

## Waste Disposal Research

A review of waste disposal research was not definitive because the major information needs identified during the review phase were at least partially being covered by other environmental research programs. Consequently, the planning team at Tetra Tech made two major recommendations, one for a more intensive review of research needs and one for a research project that would complement an existing EPA project (Tilsworth, 1982).

### Review Cold-Climate Waste Research Needs

The planning team strongly recommended a more focused review and planning effort before funds were expended on field research. Within the first three months, experts and specialists in cold regions waste disposal would be notified and invited to participate in the planning effort. A comprehensive, labor-intensive information review would be conducted and documented in an Information Report. The Information Report would be distributed in draft form to the confirmed program participants for review and comment. Following the incorporation of review comments and the examination of additional information sources identified by the reviewers, a final Information Report would be prepared and distributed to program participants.

Within the next three months, participants identified and brought into the program earlier would meet in an intensive workshop to discuss the Information Report and provide a consensus on research priorities. It is expected that workshop participants would include agency representatives, academic specialists, consultant experts, and managers and technicians actually engaged in waste management procedures at cold regions communities in the United States and Canada. Following the workshop, preliminary research plans would be developed in accordance with workshop recommendations and distributed to the workshop participants for review and improvement. After revision, final research plans would be developed to the level of detail necessary to allow responsive research proposals to be prepared.

## Effect of the Arctic Climate on Risk of Fecal Contamination

The specific research topic offered here, "Research Plan to Determine the Effect of the Arctic on Risk of Fecal Contamination," is a refinement of the research plan abstract which Tetra Tech, Inc. recommended for highest priority during the Chena Hot Springs waste disposal presentation: "Effect of Arctic Climate on Solid and Liquid Waste Decomposition." They selected the present topic because they believed it was one area in which field and laboratory research can make a new and significant contribution to the existing body of knowledge. The contribution would be significant because it would provide information on the severity of a potentially serious health hazard, and because this research will provide decay coefficients which can be used to alter the design of waste treatment and disposal systems on a fairly site-specific basis for individual cold-regions communities. Such coefficients are used routinely in developing design criteria for waste treatment systems in temperate latitudes, however, they have not been developed for cold regions.

Arctic climates may alter the life cycles of waterborne pathogens to the extent that predictions based on information from the "Lower 48" states are inaccurate. Consequently, a research plan has been devised to evaluate the effects of climatic factors on survival and growth of pathogens and their indicators.

The problem is that arctic climates differ from temperate climates in terms of temperature, light, humidity, and transport. These factors vary in range and in pattern. The effects of the arctic climate on survival and disinfection of fecal bacteria and other organisms have not been quantified and cannot be accurately predicted. Bacteriocidal effects, growth conditions, transport and mixing have significant effects on pathogenic microorganisms, and affect the exposure of human populations. With the burgeoning Alaskan population, the probability of exposure will increase due to increased sources of pathogens as well as increased use of water resources. Human exposure will depend on the interaction of sources, vectors and control measures.

Fecal pathogens include bacteria, viruses, protozoa, and multicellular parasites. Special techniques can be used to isolate and measure specific organisms but standards and criteria are often set using composite bacteriological and physical indicators. Total coliforms, fecal coliforms, and fecal streptococci are often used as indicators of fecal microorganisms. Turbidity or suspended solids are often used to assess the presence of potential risk of exposure to protozoan cysts and to parasites. These indicators may be totally inaccurate in arctic climates because of differential rates of survival, encystment, and growth of pathogens. It will be necessary to characterize conventional indicators and specific pathogens in cold climtes to adequately determine risk. Sources of fecal pathogens include all human waste disposed to the environment. The major sources will be liquid wastes from waste treatment plants and solid waste disposal sites or dumps in the bush. Survival of pathogens from these sources and potential exposure pathways should be elucidated to evaluate risk of exposure.

Several important objectives need to be satisfied for protecting the public health in Alaska. These include:

* evaluating survival of common indicator and selected specific pathogenic organisms in waste disposal sites and in ground and surface waters (fresh and marine)

* evaluating effectiveness of disinfection methods for the common indicators and selected pathogens in wastes and aquatic ecosystems

* developing and confirming methods for evaluating treatment and disposal alternatives so that the public health risks are minimized.

The tasks necessary to accomplish these objectives are integrated as shown in Figure 3. The relationships between the tasks and the inputs and outputs of the research are also delineated. The major output of this research program will be a report describing the methodology and how it can be applied by state and local government personnel.

## Habitat Modification/Manipulation Research

Although a wide range of potential effects on habitat were considered and most of these will need to be addressed in coming years, only three of the specific problems discussed were ranked highly enough by workshop participants to warrant their inclusion in the initial program plan.

### Impact of Oil Development Upon Coastal Tundra Wetlands

Expanding oil and gas development in tundra wetlands of northern Alaska is a source of increasing environmental impact. In order to develop an environmentally sound management plan, the following research objectives should be met:

* Define the major habitat types in North Slope wetlands in terms of vegetation composition, primary production and soil properties. Develop a guide for managers including descriptions of vegetation types with representative air and ground photos of these types.

* Compare impacted and control areas in each major wetland type with respect to the following disturbances: altered drainage, dust and production waters (i.e. those contaminated with oil).

* Determine which disturbances are most detrimental to sensitive habitats, and why.

* Rank habitats with respect to sensitivity to each type of disturbance.

* Recommend guidelines for habitat use and for permissible levels of each disturbance type.

Three major research approaches are recommended for study of North Slope wetlands. These approaches are complementary and should all be undertaken to achieve research objectives.

1. Carry out an extensive literature search and evaluation on the impact of oil development on coastal tundra. A great many studies have already been done in this area and the greatest initial contribution that this project could make would be a summary and evaluation of this work and a set of preliminary conclusions as to which habitats are most likely to be sensitive to environmental damage and which habitats are of particular biological importance. This literature survey would involve contact with industry and agencies as well as survey of the published literature.

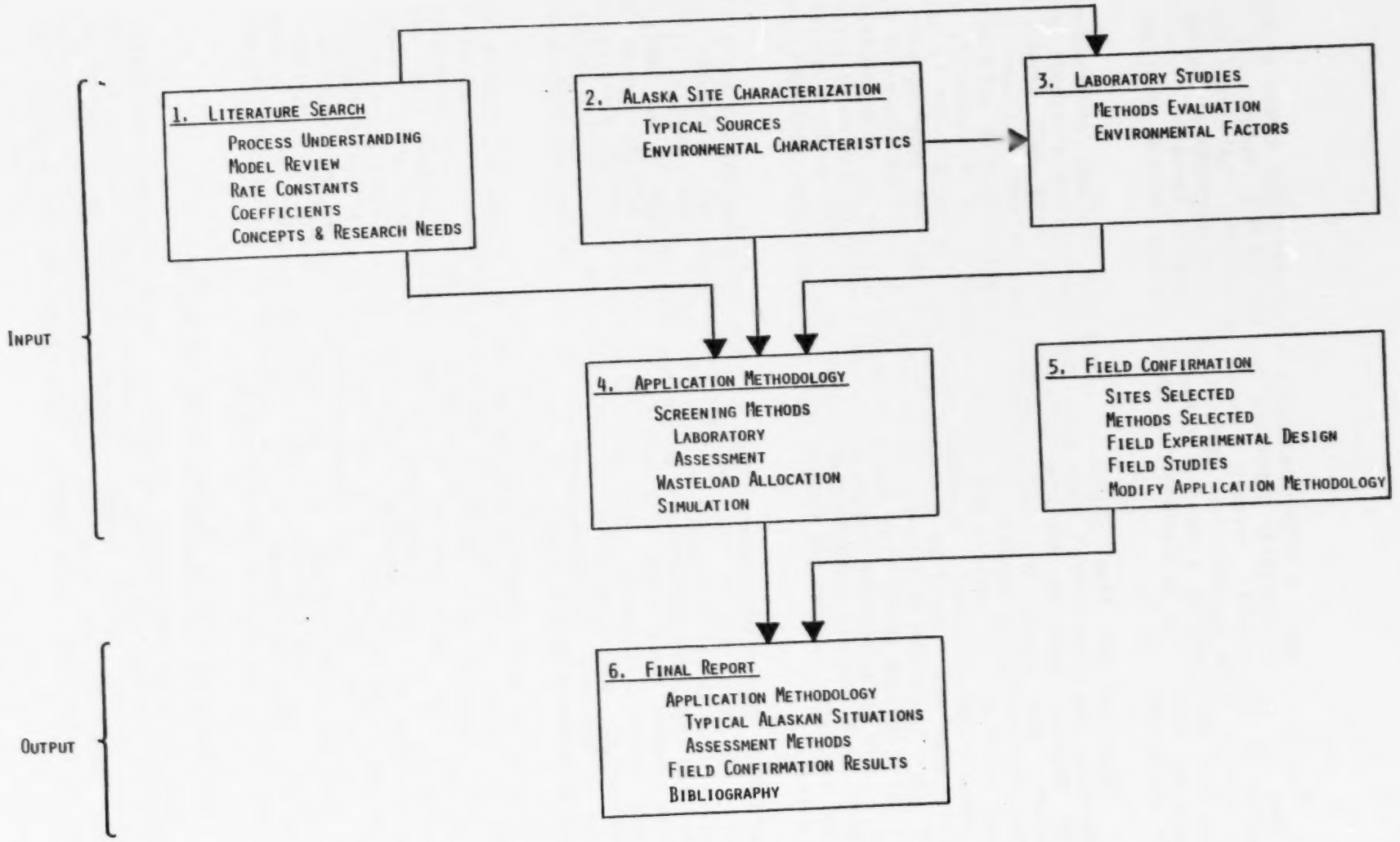


Figure 3. Integration of Tasks to Produce a Usable Methodology in Solid Waste Management.

2. Develop or adopt a simplified habitat classification scheme of major types that are (a) biologically important and (b) readily recognizable from infrared aerial photography. Produce a guide for managers that would enable them to identify these habitats from aerial or ground photography or vegetation data and that would provide a ranking of habitat types in terms of biological importance and sensitivity to disturbance. These rankings would be developed in research approaches 1 and 3.

3. Determine the time course of impact of various environmental disturbances by comparing control areas with disturbed areas of different ages. Community response would be measured in terms of altered soil properties (temperature, thaw depth, pH, salt content, and nutrient availability), vegetation characteristics (species composition, primary production and biomass by species, plant nutrient content and pattern of phenological development), and use by mammals and waterfowl. Permanent plots would be established in each dated disturbance which would be followed by non-destructive sampling over a period of years to confirm that comparison of different-aged disturbances at one time is a valid measure of the time course of community recovery or degradation. Disturbance types to be studied include several which would receive major effort (dust, impoundment, and oil production waters) and others which would be studied with lesser intensity as time and funding permit ($SO_2$ pollution, salt, drilling mud, and brine).

Experimental design will depend upon accurate aging and determination of the nature and severity of the initial disturbance, as determined by reconstruction from aerial photography of different ages. Where possible, it is crucial to find replicate disturbances of the same age and type in each habitat type and to compare these areas with controls of the same habitat type which were present before disturbance. This would be determined from pre-disturbance aerial photography and examination of peat structure in disturbed sites. Prudhoe Bay is the only reasonable study site because of the long history of oil-related development on the site.

The results of this research program should have direct application to EPA's needs in Alaska. It is designed to provide a preliminary (2 year) and a final (5 year) managers' guide that will enable EPA or any other management agency concerned with tundra wetlands to define important wetland types and define sensitivity to various disturbances in each of the major wetland types. The manager can then make environmentally sound decisions on permit applications using the managers' environmental guide and either aerial or ground photography or minimal vegetation data. In future years, if extensive large-scale vegetation mapping or photography were available for North Slope wetlands, long-range management plans could be developed using the manager's guide in such a way as to concentrate development in less sensitive or critical habitats and avoid environmentally important or sensitive areas.

Impact of Logging on Interior Alaskan Stream Ecosystems

The subarctic taiga environment of interior Alaska (between the Alaska Range to the south and the Brooks Range to the north) is among the least studied forest regions of the United States. Interior Alaska is a region of discontinuous permafrost and extensive forest interspersed with low-lying wetlands and above-treeline alpine tundra. This region has the potential for

vastly accelerated development and exploitation, with conflicting management pressures already brought about by increased populations and volatile land ownership issues.

Quantitative, documented information of either undisturbed or managed subarctic upland landscapes and associated stream systems is extremely scarce. Agency response to state and federal land management and regulation directives, notably Section 208 of Public Law 92-500 (non-point source pollution), is hampered by the current lack of knowledge of both the permafrost-dominated taiga upland environments, and the response of that environment to resource management practices.

The study recommended here is designed to investigate specific impacts of timber harvest in interior Alaska's forests on headwater stream systems. This research would be best done at Caribou-Poker Creeks Research Watershed in central Alaska where the air quality group is recommending a major research focus. The two groups could use many of the same logistic facilities and environmental information.

Effects of vegetation removal would be examined by both "before and after" studies and "upstream-downstream" studies following timber harvest. The guiding hypothesis is that vegetation removal will shift the energetic basis of the stream community from dependence upon leaf input from riparian vegetation to increased primary production within the stream itself. This shift should produce a predictable change in community structure of stream invertebrates and changes in utilization of invertebrates by stream fishes. Primary production by stream autotrophs, secondary production of stream invertebrates and community structure of primary producers and invertebrates would be used as integrative measures of changes in stream energetics following vegetation removal. Changes in streambed sediment loads would be investigated as well.

The primary "customers" for the knowledge to be gained in this research are natural resource managers operating in Alaska's subarctic, and the agencies/personnel having oversight and regulatory authority over both natural resources management and environmental protection. In Alaska, state regulatory agencies are currently attempting to exercise oversight on forest management operations, in accord with the 1978 Alaska Forest Practices Act. The agencies are handicapped in developing guidelines and "Best Management Practices," because of lack of quantitative documentation of the impacts of forest harvest on streams in the subarctic. The results of this research will provide sorely needed factual data on such effects. The results may substantiate current policy or indicate need for revision; in either case, the documentation is needed to help ensure that an appropriate level of environmental protection accompanies forest harvest in the taiga uplands.

Gravel Removal from Riparian Habitats

Consideration of the need for habitat protection should begin with habitats that support an unusually diverse, abundant, or valuable biological resource and with habitats that are directly threatened by development activities. When these are found in a single habitat type, special attention is called for. This is the case for riparian habitats of the arctic slope of Alaska.

The major river systems of the arctic slope flow north from the Brooks Range to the Arctic Ocean, bringing nutrient-rich basic sediments to the acid tundra of the Arctic Coastal Plain. The plant and animal communities of arctic riparian systems are richer in species and higher in productivity than surrounding tundra. The willows and herbaceous perennial plants of riparian communities are highly preferred by a number of herbivorous animals. Moose extend all the way to the arctic coast and are increasing in abundance in riparian communities; they are rarely found away from riparian willow stands. The rapid increase in the musk ox population introduced to the Sadlerochit River draining is related to their use of extensive riparian communities. Populations in the Canning and Hulahula River drainages, with less extensive riparian communities, have not increased as rapidly. Riparian areas are also the most important winter and spring habitat for ptarmigan, which feed upon willow buds and catkins.

The recommended research approach would be to:

* utilize aerial photography and ground truthing to provide a classification and survey of riparian habitats of the arctic slope of Alaska, identifying those that are particularly productive, critical to animal populations or vulnerable to development

* establish an intensive study site along the Saganavirktok River, easily accessible from the Dalton Highway to:

    1) document the plant diversity, community structure, and productivity of representative riparian stands with respect to seasonal flooding and stage of riparian succession

    2) document the use of riparian communities by grazing vertebrates, and nesting birds, and assess the importance of riparian communities to populations of these animals on the arctic slope of Alaska.

Riparian habitats are particularly vulnerable to development for at least two reasons. First, they provide an easily accessible and abundant source of gravel for the roads and work pads that are needed for development in the arctic. The huge quantity of gravel used at Prudhoe Bay has been removed from the Sagavanirktok, Putuligayuk and Kuparuk Rivers. Gravel removal produces a severe but local loss of habitat. In addition, river valleys are the most economical and feasible routes for roads and pipelines, as is clearly indicated by the routing of the oil pipeline and Dalton Highway. The likely construction of a gas pipeline, which could require a work pad entirely separate from that of the oil pipeline, and the development of new oil and gas fields with feeder lines to the major oil and gas pipelines, will contribute to a cumulative and regional alteration or loss of riparian habitat. Evaluation of these losses must enter the early phases of development planning to prevent unacceptable losses of valuable habitat.

## PROGRAM IMPLEMENTATION

The Pacific Northwest Laboratory is implementing and administering the Environmental Protection Agency's Cold-Climate Environmental Research Program in accordance with Interagency Agreement No. AD-89-F2A189.

### Approach

PNL intends to apply as many of the available dollars as possible directly to productive research through efficient program management. To do this, and still be responsive to new situations as they develop, PNL's effort has been divided into two categories, program administration and technical assistance.

#### Program Administration

The primary research to be conducted under this contract will be performed under subcontract. PNL will conduct all necessary administrative activities pursuant to the issuance and monitoring of subcontracts for research as follows:

* Issue subcontractor RFPs, scopes of work, or other solicitations for work as required by the EPA project officer.

* After peer review and approval by the project officer, provide funding of projects through subcontracts or other appropriate funding instruments.

* Monitor technical progress and fiscal expenditures on subcontracts.

* Provide overall management of a quality assurance (QA) program to assure that environmental measurement data generated by subcontractors comply with an approved QA program plan. PNL will include in each statement of work for each subcontractor specific guidance on QA requirements. Each subcontractor will be required to complete an approved QA project plan immediately after contract award. PNL will monitor subcontractor compliance with project QA plans.

* Coordinate with other federal and state agencies and private businesses and institutions to prevent duplication of effort and, where possible, explore the possibility of cooperative agreements where mutual research interests are identified.

* PNL will be responsible for timely reporting of results to the EPA project officer. At a minimum, an annual report will be prepared. As each subcontract is completed, PNL will prepare a final report on the subcontract element and forward it to the project officer within 30 days. In addition, within three months of the beginning of each budget year, PNL will submit a brief report on RFP's issued and responses to those RFP's by potential subcontractors for conduct of various portions of the Cold-Climate Research Program.

#### Technical Assistance

In addition to the managerial and administrative activities defined above, PNL will perform additional work upon request by, and as agreed to with, the EPA

project officer. These will be primarily synthesis and integration tasks such as the following:

* PNL's management of the program will be under the purview of an EPA project officer who will be advised by two committees. PNL will coordinate meetings and the EPA project officer will chair both committees. The first committee will consist of a scientific peer review committee which will provide technical and scientific advice and guidance to PNL in order to assure that all awarded subcontracts are of the highest scientific quality. The second committee will 1) provide advice on the program priorities, 2) review for relevance the proposed subcontracted research, 3) assure that program components meet, as closely as possible, all federal and state agency needs, and 4) serve as the Agency Oversight Committee for all EPA-sponsored cold-climate research.

* Synthesis and integration of research results may be required from time to time in the form of reports, brief background papers, position papers and draft reports on various aspects of the effects of pollutants in the cold-climate environment. PNL will prepare such reports as mutually agreed to with the EPA project officer.

* PNL may hold periodic symposia or other scientific and technical meetings and workshops. These workshops will bring together state and federal officials and scientific and technical experts in appropriate disciplines, at a time and place which is approved by the EPA project officer in order to conduct state-of-the-art analyses. Additional workshops may be required in order to bring together appropriate experts and environmental managers from state and federal agencies as well as the scientific community in order to disseminate information and current results from the Cold-Climate Research Program to the user community.

* PNL may also fund assessments or problem analyses in various resource areas as the basis for making priority research decisions.

* Finally, periodic reports of the proceedings of workshops, symposiums, other meetings, and meetings of the two oversight committees will be submitted at irregular intervals. PNL will also provide summarized state-of-the-art documents and syntheses of research results from various subcontract tasks assembled in a timely fashion in appropriate format for EPA use. The exact timing of these reports is not known at this time, but it is anticipated that two or three reports which assess or synthesize data from two or more subcontract areas will be required each year. The required format and timing will be prescribed by the EPA project officer with concurrence by PNL.

It is expected that, as a result of the environmental research conducted under this program, the EPA will be better able to reach informed decisions on environmental problems under EPA jurisdiction. During the course of the work the results will be disseminated to other concerned agencies and individuals.

Current Program Status

Following development of the research plans summarized above, the Agency Oversight Committee involving representatives from about 20 federal, state and

local agencies was formed as an advisory body to the Cold-Climate Research Program (Table 8). This committee provides a mechanism for integrating EPA research with parallel efforts and interests of other agencies. This committee will meet at least once a year, prior to the generation of RFP's, to review and comment on the EPA's research plans for the coming year. This enables program managers to consider new perspectives and accommodate needs and interests of other agencies in the actual conduct of research. In addition, where agency responsibilities overlap, particularly on problems too large to be addressed using single-agency resources, this committee serves as a focal point for joint or cooperative research efforts.

At its first meeting, the Agency Oversight Committee utilized the computer-aided process to prioritize the research plans described above as a committee of the whole and in selected subgroups (Table 9). The research on Vehicle Emissions and Alternate Fuels had already been implemented at the time of the meeting. Although all 17 of the remaining research plans are considered important, the priorities estabished by this committee are being used as the primary guide in determining the order of their implementation (Table 9). It is expected that approximately ten of the higher priority plans will be implemented during FY 1982 and 83 at a combined funding level of 600 to 1100K.

To ensure that resulting research would best meet the concerns of all agencies, committee members volunteered staff time and meeting facilities to assist in refining work statements before the work begins.

A second advisory group, the Technical Review Committee, helps select winning bidders from among those responding to requests for proposals. Members of both advisory groups will be involved in annually reviewing results of the research.

TABLE 8. Agency Oversight Committee for EPA
Cold Climate Environmental Research Program Presentation

| Agency | Representative | Position |
|---|---|---|
| Alaska Department of Environmental Conservation | Leonard Verrelli | Supervisor, Air Quality Program |
| Alaska Department of Fish and Game | Kimbal Sundberg | Habitat Division Representative |
| Alaska Department of Natural Resources | Allan Carson | Deputy Director, R&D Division |
| Alaska Council on Science and Technology | David Hickock | Director |
| Municipality of Anchorage | James Sweeney | Manager, Environmental Resources |
| North Slope Borough | Ray Dronenburg | Chief Biologist |
| U.S. Environmental Protection Agency: | | |
| Environmental Research Lab. at Research Triangle | Ron Bradow | Air Quality Division |
| Corvallis Environmental Research Lab. | Norman Glass | Senior Science Advisor |
| Washington Office of R&D | Alfred Galli | Director, Air & Energy Division, Office of Environmental Processes and Effects |
| Juneau Alaska Operations Office | Ronald Kreizenbeck | Manager |
| U.S. Fish and Wildlife Service | John Morrison | Chief, Division of Technical Services |
| U.S. Forest Service | Charles Slaughter | Principal Watershed Scientist |
| U.S. National Marine Fisheries Service | Theodore Merrill | Deputy Director |
| U.S. Bureau of Land Management | H. William Gabriel | Research Coordinator |
| U.S. Minerals Management Service | Jerry Imm<br>Jon Nauman | Chief, Environmental Studies<br>Office of Leasing & Environment |
| U.S. Army Cold Regions Engineering & Research Lab | Larry Johnson | CRREL Representative |
| U.S. Army Corps of Engineers | Kirk Shadrick | Assistant Chief of Construction |
| U.S. Department of Energy | Bill Osborn | Ecological Research Division |

TABLE 9. Results of Research Prioritization by Agency Oversight Committee.

| | All Participants | EPA | EPA, ADEC, Anchorage | FWS, ADF&G, BLM | Federal Agencies | State & Local Agencies |
|---|---|---|---|---|---|---|
| 1 A Study of Pollutants, Especially Particulates, In Alaskan Urban Centers and Their Human Health Effects | 5 | 1 | 1 | 13 | 8 | 1 |
| 2 Using Observed Co and Artificial Tracer Concentrations to Predict Dispersion of Air Pollutants under Stable Atmospheric Conditions | 8 | 4 | 2 | 11 | 13 | 2 |
| 3 Fairbanks Transportation System Characterization | 16 | 9 | 6 | 10 | 14 | 15 |
| 4 Investigation of Photochemistry at 65° N Latitude | 13 | 6 | 5 | 14 | 11 | 6 |
| 5 Industrial Air Pollutant Downwash and Deposition and Their Potential Effects (Acid Precipitation) | 14 | 16 | 9 | 16 | 12 | 7 |
| 6 Concentrations, Composition and Transport of Pollutants Contributing to Arctic Haze | 11 | 13 | 13 | 8 | 10 | 11 |
| 7 Background Concentrations of Organic and Inorganic Compounds | 17 | 14 | 15 | 17 | 17 | 17 |
| 8 Summary and Comparison of the Existing State of Knowledge on Cold-Climate Air Pollution - Before and After Completion of 5-Year Program | 12 | 3 | 10 | 9 | 15 | 5 |
| 9 Asbestos Levels in Rural Alaskan Drinking Water | 6 | 8 | 4 | 7 | 6 | 14 |
| 10 Cost-Effective Bio-Indicators of Marine Pollution | 4 | 12 | 14 | 4 | 2 | 8 |
| 11 Biodegradation and Toxicity of Hydrocarbons in Oiled Waters | 3 | 5 | 12 | 2 | 1 | 13 |
| 12 Ecosystem Impacts of Placer Mining | 2 | 10 | 7 | 1 | 4 | 3 |
| 13 Review Cold-Climate Waste Research Needs | 15 | 17 | 17 | 15 | 16 | 9 |
| 14 Effect of Arctic Climate on Risk of Fecal Contamination | 10 | 11 | 8 | 12 | 9 | 10 |
| 15 Impact of Oil Development upon Coastal Tundra Wetlands | 1 | 2 | 3 | 3 | 2 | 4 |
| 16 Impact of Logging on Interior Alaskan Stream Ecosystems | 9 | 7 | 11 | 6 | 5 | 16 |
| 17 Gravel Removal from Riparian Habitats | 7 | 15 | 16 | 5 | 7 | 12 |

*KEY

ADEC . . . . . .Alaska Department of Environmental Conservation
ADF&G. . . . . .Alaska Department of Fish & Game
Anchorage . . . .Municipality of Anchorage
BLM . . . . . .Bureau of Land Management
EPA . . . . . .Environmental Protection Agency
FWS . . . . . .U.S. Fish & Wildlife Service

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